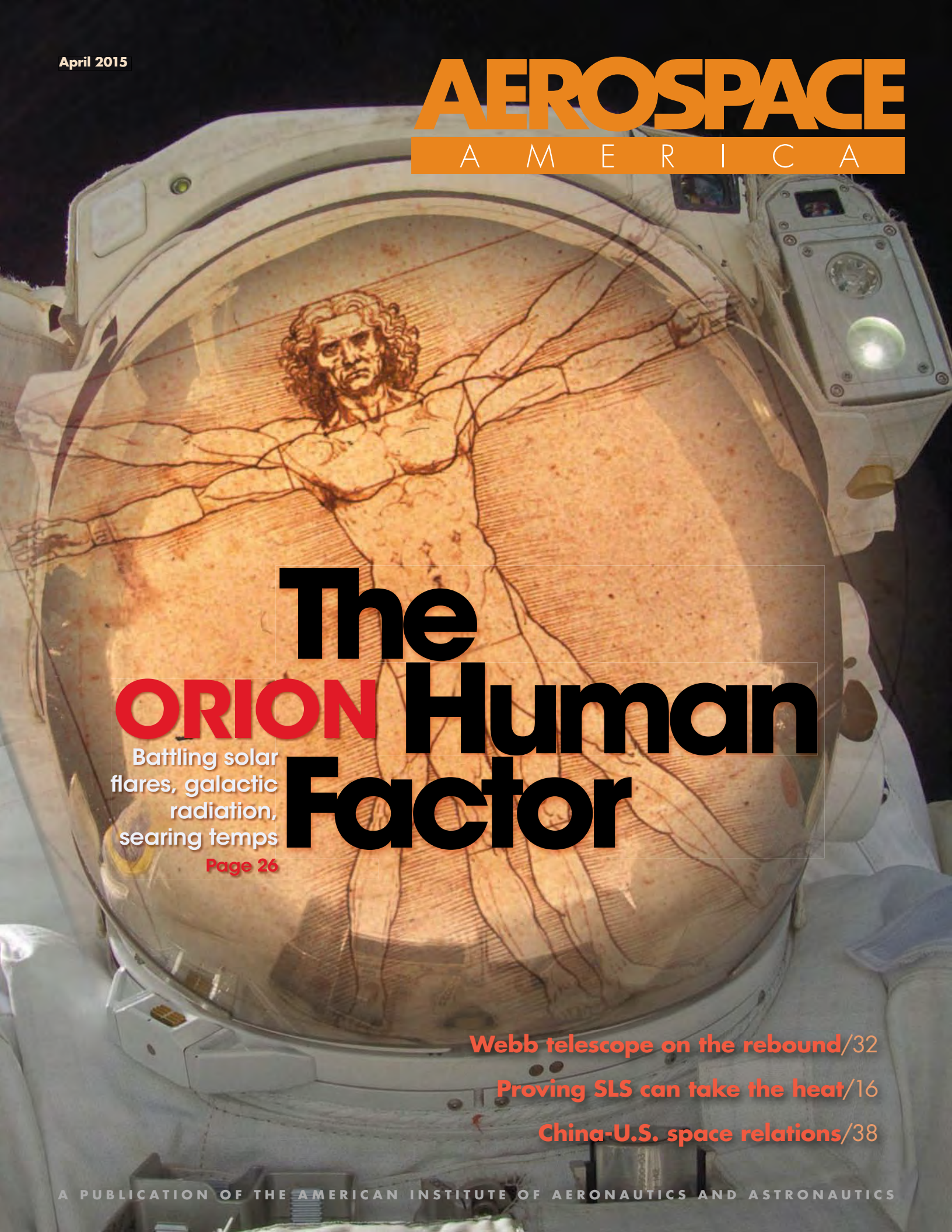
April 2015

AEROSPACE AMERICA



The ORION Human Factor

Battling solar flares, galactic radiation, searing temps

Page 26

Webb telescope on the rebound/32

Proving SLS can take the heat/16

China-U.S. space relations/38

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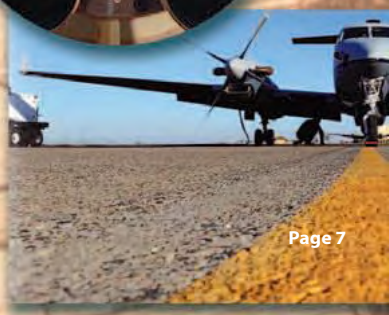
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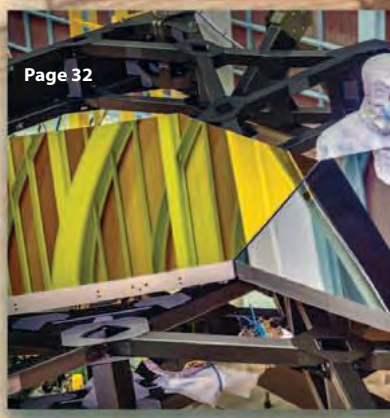
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AEROSPACE AMERICA

April 2015













DEPARTMENTS

EDITOR'S NOTEBOOK 2
NASA's course

LETTERS TO THE EDITOR 4
Give NASA the money; a broader look at CFD; the Harford influence

IN BRIEF 6
Microbes on Mars; Project Liberty; SETI goes infrared; Iridium terminals

INTERNATIONAL BEAT 10
Pushback on tech spending; cost-effective helo training; IXV flight details

SCHOOL ZONE 14
Know your winglets

ENGINEERING NOTEBOOK 16
Modeling heat off rocket engines

THE VIEW FROM HERE 20
NASA's bid to grab an asteroid — 9 things to know

OUT OF THE PAST 46

CAREER OPPORTUNITIES 48

FEATURES

THE HUMAN FACTOR 26
Flying Orion to the moon will take astronauts out of low Earth orbit for the first time since the 1970s. What are NASA and Lockheed Martin doing to keep Orion astronauts safe for those missions?
by Debra Werner

'YEAR OF THE TELESCOPE' 32
NASA is pushing development of the Webb telescope into a critical assembly and test phase at a time when investigators at the Government Accountability Office warn there is little room left for error.
by Ben Iannotta

ANALYSIS: BRINGING CHINA INTO THE SPACE FOLD 38
Faced with an increasingly active Chinese space program, the U.S. has adopted a "keep your competitor close" strategy.
by Marco Cáceres

TAMING THE UNMANNED SKIES 42
Safety technologies and regulations have lagged far behind the exploding market for small unmanned aircraft.
by Debra Werner and Philip Butterworth-Hayes

BULLETIN

AIAA Meeting Schedule B2
AIAA News B5
AIAA Propulsion and Energy 2015 B12
B12 AIAA Courses and Training B15

ON THE COVER
Da Vinci's iconic Vitruvian Man drawing, circa 1490, superimposed on astronaut Aki Hoshide's spacewalk helmet. Graphic by Jane Fitzgerald.

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AIAA
Shaping the Future of Aerospace

Editor's Notebook



NASA's course

It's almost a maxim inside Washington, D.C.'s Beltway that NASA is rudderless and twisting in the wind, especially when it comes to human exploration.

President Obama's science and technology advisor, John Holdren, pushed back on that idea in a March event organized by AIAA at the National Air & Space Museum to commemorate the 100th anniversary of the founding of NASA's predecessor, the National Advisory Committee for Aeronautics.

"While some have claimed — on what basis I have been unable to fathom — that our program of human exploration is adrift," Holdren said, "we are on a clear and compelling path to sustainable human exploration of the solar system."

Is Holdren right or wrong? The cynic in me wants to take the image of an agency adrift and run with it, but Aerospace America dug into some of NASA's biggest projects for this edition of the magazine, and I don't see evidence for the charge.

I suspect the real problem is that some critics in the space community and Congress don't like where the rudder is pointed. Fair enough, but wonks and lawmakers ought to be able to debate the merits of the course without claiming there isn't one. This edition of the magazine provides lots of fodder for that discussion.

Our cover story, "Orion: The Human Factor," shows that NASA and Lockheed Martin are addressing the safety problems that Orion must solve, no matter the precise destination.

In "NASA's bid to grab an asteroid," columnist Tom Jones provides a thought-provoking primer on the proposed Asteroid Redirect Mission. The piece made me wonder how the debate over which celestial body astronauts ought to visit — the moon or an asteroid — could become a partisan issue. It's a sign of the times I guess. Whatever the destination, NASA and the White House seem pretty determined to push humanity farther into space, which ought to please advocates of human exploration more than they should be displeased over the choice of destinations. Yes, the budget and out-year-funds are a problem, and an even bolder mission to Mars in the 2030s remains aspirational. But having aspirations is not a bad thing, and NASA is hardly unique in having aspirations greater than its ability to pay for them.

In the article I reported, "Year of the telescope," we see a NASA that is fighting to get the James Webb Space Telescope done after years of cost and schedule overruns and with the Government Accountability Office sounding a fresh alert about shrinking schedule reserves. I don't know what lies ahead, but the rudder there is pointed toward keeping NASA on course to continue the Hubble's legacy through Webb and beyond.

NASA is on a challenging course, and that's how it should be.

Ben Ianno tta
Editor-in-Chief

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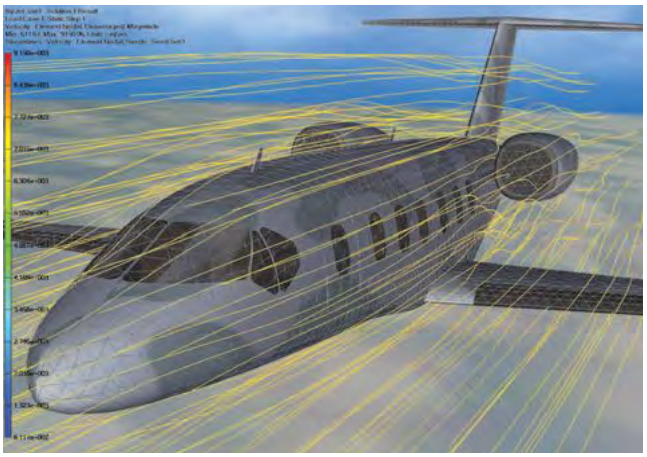
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Give NASA the money

Ben Iannotta's column on page 3 in the February issue of Aerospace America [page 3] reflects a distressing opinion of NASA and its potential. He writes that "all elements of NASA's portfolio must compete with each other based on their costs and likely contributions to human progress. ...Proposals must be judged… on the economic value they might bring."

Mr. Iannotta believes our nation's aerospace brainpower should help humanity reach its full potential to live in a clean, sustainable, peaceful planet. He asserts that "contributing to human progress" is NASA's core mission and that mission could be undercut if human spaceflight is "done wrong."

By Mr. Iannotta's social worthiness criteria, the 1975 docking in space of Apollo-Soyuz (not the landing of a human on the moon) might be judged NASA most worthy moment. This cost-effective mission, accomplished with surplus equipment and veteran engineers and astronauts who had little else at the time to keep them busy, drastically lowered Cold War tensions, thus promoting world peace.

In regard to NASA's manned spaceflight programs, Mr. Iannotta ominously warns "costs will have to be controlled…" This reflects his basic ignorance of our fantastic monetary system. During the Apollo moon landing program the United States was fighting an expensive Asian war, financing vast new social welfare initiatives and pursuing a costly arms race with the Soviet Union. Nevertheless, plenty of money was always there for NASA because our incredible monetary machine can print whatever funds we need. It's not a zero sum game where there is only so much money in the pot to go around. If the will is there, the country can come up with the cash to pay for any space effort. If we want to send a human to Mars, lack of money is certainly no excuse for not going.

If the American taxpayers could choose on their federal tax returns just where to spend their money, they would pick manned space flight above all other NASA initiatives.

Mr. Iannotta writes, "the U.S. will need to pace itself…" Now this is a real recipe for failure. Whether it's a new fighter plane or a rapid transit system "pacing itself," extending programs (for several decades in the case of the F-35 fighter plane) will guarantee that the ultimate cost will be astronomical. Private industry in America knows that the cheapest project is the one that is finished in the shortest time. Only government programs can afford the waste that is inherent in "pacing itself."

NASA has been on a severe financial diet for years and like a starving man, it is now very weak. The main thing that keeps the agency going is that many taxpayers still remember the excitement of the Apollo program and want to do it again. Give NASA lots more money. It might still be able to hire back some of the great talent it lost with the cancellation of the Space Shuttle.

With appropriate funding we can have a man on Mars in a decade. The resulting return from stimulating science and technology in this country will be incalculable.

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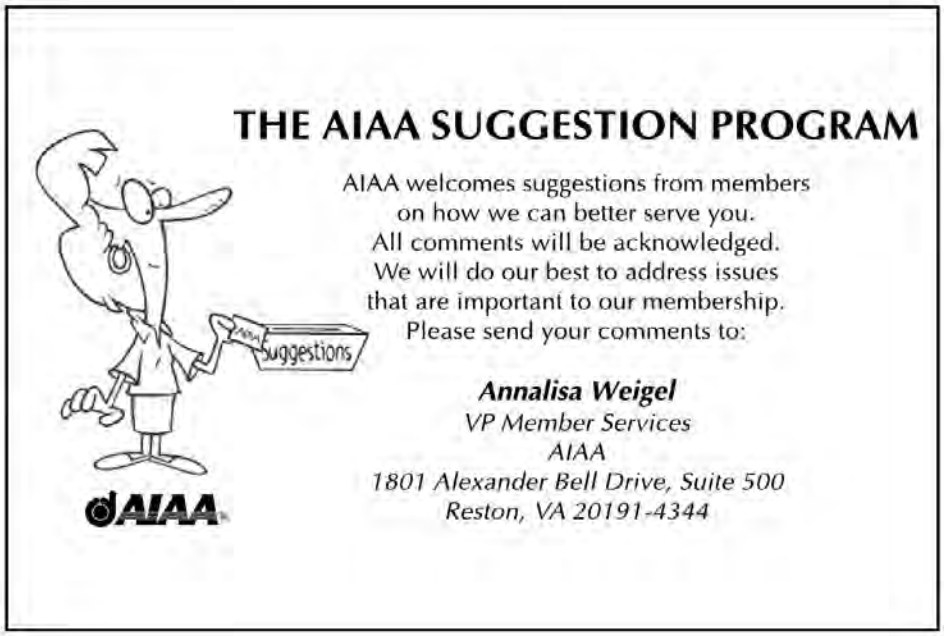
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Manned, sooner the better: Sometimes I agree with [the Editor's Notebook], sometimes I don't. The February 2015 notebook [page 3] on NASA'S "potential" falls in the latter camp.

Cutting to the chase, I believe that we simply don't have time to not be heavily pursuing manned missions to the planets and, hopefully, beyond. In a word, actually two: global warming. Whether man-made or not, we are faced with a survivability issue. You and I will be long dead by the time our species is in true jeopardy, but our great-grandchildren may not.

Yes, we are learning more and more with wonderful unmanned scientific missions, but to what end, if we aren't around very long to enjoy the fruits of our discoveries?

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A broader look at CFD

The article "Wanted: More focus on CFD" [January, page 22] appropriately captures the essence of current R&D work in computational fluid dynamics. It does so by pointing out that a current goal of R&D is to make CFD useful for off-design conditions, potentially allowing to explore more daring designs, and by identifying a key obstacle to achieve this goal: the reliance of CFD on approximate mathematical models. To overcome this obstacle, the article suggests to replace such models — which are "wrong" — with "pure computation," and goes further by advocating the development of high-performance-computing (HPC) hardware and algorithms.

In making such a proposal, the article unfortunately misses the opportunity to address two critical questions:

(1) Is "pure computation" actually feasible in the near future, not only for the aerodynamics problems emphasized in the article, but also in problems with broader ranges of scales such as combustion and multiphase flows?

(2) Rather than discarding supposedly wrong mathematical models, can we design models that, although approximate, could capture the relevant physics more accurately/efficiently than current ones by — and this is important — taking advantage of HPC? Chemists, material scientists and meteorologists (and some CFD engineers) have been working on these types of models, examples of which include multiscale models and superparametrizations. Future articles in Aerospace America about CFD should address these important questions.

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The Harford influence

I would like to add my deep appreciation to the tribute and history that Jerry Grey provided in recounting the contributions of Jim Harford to AIAA and, more broadly, to the aerospace community [February, page 4]. My appreciation is personal — Jim and Jerry were incredibly positive influences on me, both in the early stages of my professional engineering career and in the start-up of The Planetary Society.

Jim was terrific in getting young people involved in the institute. AIAA was (and is) the leading representative of the professional aerospace engineering community and when Carl Sagan, Bruce Murray and I contemplated starting a popular organization to support space exploration, we very quickly turned to Jim and Jerry for their advice. They were very encouraging and helped us think through many of the issues that a nonprofit startup needs to consider. Jim in particular was, as Jerry states, cheerful and positive with his encouragement.

I also worked with Jim closely in building to help develop an international outlook for The Planetary Society. Jim and I both built up strong relationships with the (then) Soviet Union as well as in Europe and Japan. Jim (and Jerry) contributed a great deal to the global outlook of AIAA and the development of space exploration as a global enterprise.

In summary: Thanks, Jim.

Dr. Louis Friedman
Executive Director Emeritus
The Planetary Society

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Events Calendar

April 13–15
EuroGNC 2015, 3rd CEAS Specialist Conference on Guidance, Navigation and Control
Toulouse, France
Contact: Daniel Alazard, +33 (0)5 61 33 80 94, alazard@isae.fr, w3.onera.fr/eurognc2015

April 13–17
2015 IAA Planetary Defense Conference
Frascati, Italy
Contact: William Ailor, 310.336.1135, william.h.ailor@aero.org, www.pdc2015.org

May 5
AIAA Fellows Dinner
Crystal City, VA
https://www.aiaa.org/FellowsDinner2015

May 6
Aerospace Spotlight Awards Gala
Washington, DC
Contact: 703/264-7500

June 4
Aerospace Today...and Tomorrow: An Executive Symposium
Williamsburg, VA
Contact: 703/264-7500

June 16–19
7th International Conference on Recent Advances in Space Technologies — RAST 2015
Istanbul, Turkey
Contact: Capt. M. Serhan Yildiz, +90 212 6632490/4365 syildiz@hho.edu.tr or ***rast2015@rast.org.tr***



Keeping Mars pristine

If scientists ever find microbes on Mars, they'll want to be sure the organisms didn't get there by stowing away on a robotic rover or lander during their time in the factory.

NASA maintains a library of microbes known to stubbornly inhabit spacecraft clean rooms. Scientists know that if they find any of those on Mars, it's likely the microbes weren't native to the planet. Better would be to know whether any of those could survive in the Martian environment at all and, if so, for how long. To find out, NASA has begun a series of high-altitude balloon flights called E-MIST, short for Exposing Microorganisms in the Stratosphere.

"We are taking up terrestrial microbes [by balloon] to see how they respond to that environment," said David J. Smith, the E-MIST principal investigator at NASA's Ames Space Biosciences Division in California. "By sending micro-organisms into the stratosphere, it is analogous to the Martian surface. We want to know what happens in that environment. Can they survive and to what extent are they dying off?"

Microbes are loaded into a 36-kilogram (80-pound) carrier built at Kennedy Space Center's Prototype Development Lab. Four doors open at stratospheric altitude to expose the microbe samples for predetermined amounts of time.

The next flight of this setup over the New Mexico desert could be later this year — perhaps in August or September.

On E-MIST's first mission — a five-hour journey to 125,000 feet last August from Fort Sumner, New Mexico — the carrier contained bacillus pumilus, a highly resilient spore-forming bacteria strain originally isolated from NASA's Odyssey spacecraft being prepared for a Mars sendoff. Spore-forming is a survival strategy for certain bacteria that enables them to persist in extreme conditions, including space and perhaps on Mars.

The environment at 125,000 feet is super dry, irradiated and hypobaric, meaning the air pressure is lower than at the surface, Smith said. Those are conditions that mimic Mars. The flight was a shakeout mission, Smith said last August.



A high-altitude balloon designed to test how to avoid microbial contamination on Mars lifts off from New Mexico.

NASA

"We only tested the hardware on the first flight. The exposure was 2 seconds long, so all the microbes survived just as we would expect them to," Smith added.

On a future flight, the exposure will be longer, perhaps up to 8 hours. Ground simulations with another bacillus species indicate that 99.9 percent of sunlight samples in the stratosphere will be killed within 6 hours. However, bacillus pumilus is much more radiation resistant than the previous species tested on the ground. "We don't know what the stratosphere tolerance will be; this kind of experiment has never been conducted before," Smith said.

The E-MIST effort is focusing on ways to have a say in the development of procedures for preventing the microbial contamination of Mars by robotic spacecraft.

The E-MIST hardware was built through funding from Rocket University, which is a training program paid for by the NASA Office of the Chief Engineer. Funding also comes via a research grant from the Kennedy Space Center.

While the NASA library of spacecraft facility microbes is huge, the intent is to start with some of the hardiest known microbes from the archive.

While E-MIST can house spore-forming bacteria that have remarkable resistance to atmospheric extremes, non-spore-forming bacteria, archaea, fungi, algae, and viruses can also be examined.

Casting an eye to the future of human explorers stepping onto the Red Planet, Smith said: "We need to keep Mars as pristine as possible, for as long as possible, before astronauts get there."

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Liberty aircraft transition underway

The U.S. Air Force's C-12-based Project Liberty intelligence aircraft are changing hands after 400,000 hours of flight in Iraq and Afghanistan, and the transition will mean some overhaul work to get them ready for their new operators.

Eight of the fleet of the Air Force's 41 MC-12W Liberty planes have been transferred to the U.S. Army. Another 13 of the aircraft will go to the U.S. Special Operations Command at the Air National Guard Wing at Oklahoma City, Oklahoma, according to the Air Force. The service hasn't disclosed where the remaining 20 planes will end up.

L-3 Communications' unit in Greenville, Texas, will handle the overhaul of the aircraft as they transition from the Air Force to the Army and Special Operations. That will include swapping out some of their intelligence, surveillance and reconnaissance hardware and software, as well as upgrading or refurbishing hydraulics, avionics, cockpits and landing gear, as necessary.

Despite the rigorous flight conditions experienced by the MC-12Ws during their first five years, the aircraft should still be able to stick to their projected lifespan of 25 to 30 years, said Col. Steve Clark, fixed-wing project manager for the Army's Program Executive Office for Aviation. Other than slight changes to the cockpit instrumentation, as read by Army pilots versus Air Force pilots, Clark said, there will be few differences to the airplane when it is flown by the Army. During a transition period that will last until Sept. 30, Air Force pilots will fly the aircraft together with the Army pilots.

The first Liberty planes were built on used civilian C-12 King Airs. The fleet was rushed into service in 2009 to increase the amount of airborne video and signals intelligence available to U.S. intelligence analysts and troops in Iraq and Afghanistan. According to the Air Force, the MC-12Ws were the fastest-delivered weapon system — only eight months — since the fielding of the P-51 Mustang in World War II.

"The King Air is built like a truck. It takes a beating, and it's really hard to take down," said Tobin Shackelford, business development director for Platform Systems Inc., an aircraft modification and engineer company in Lexington Park, Maryland, that does modifications for the King Airs. "You can beat the thing up, and it still delivers great performance."

For the Air Force, the aircraft typically flew with two pilots and two or three sensor operators. The MC-12Ws are modified Super King Air 350 and 350ERs, with 57-foot-11-inch wingspans. Powered by Pratt & Whitney PT6A-60A engines, they fly at low and medium altitudes — up to 35,000 feet — at speeds of up to 312 knots per hour (360 mph). The 350 version has a range of 1,500 nautical miles, with a maximum takeoff weight of 15,000 pounds, while the 350ER version can fly 2,400 nautical miles and has a maximum takeoff weight of 16,500 pounds.

For the Army, the eight MC-12Ws will become part of the Enhanced Medium Altitude Reconnaissance and Surveillance System program, which has 24 aircraft altogether.

Keith Button
buttonkeith@gmail.com



An Air Force MC-12W Liberty at Beale Air Force Base, California. The Air Force is transferring control of at least eight Liberties to the U.S. Army.

U.S. Air Force

Search for ET goes infrared



University of California

The new SETI tool will be mounted to the Nickel telescope at the Lick Observatory on Mount Hamilton just east of San Jose, California.

Detecting communications from faraway folks has been a passion for astronomer Frank Drake for decades. Back in 1960, he carried out the first modern search for extraterrestrial intelligence by listening for radio signals using a telescope at Green Bank, West Virginia.

Drake is among the SETI experts who wonder if advanced civilizations might be communicating via lasers rather than radio waves. The first searches for evidence of optical communications came up as empty as the searches for radio signals, but those efforts were focused on visible light. Drake is a member of an international team that's about to start looking for pulses of near-infrared light.

From an extraterrestrial's perspective, there might be good reason to communicate across interstellar distances using infrared lasers. "The Milky Way is filled with gas and dust that absorbs optical light, and if aliens were to communicate across great distances — hundreds to thousands of light years — they would use lasers that are less obscured, like infrared lasers," said Shelley Wright, principal investigator for the SETI project at the University of California at Berkeley's Department of Astronomy.

The team plans to mount the Near-infrared Optical SETI (NIROSETI) instrument that makes use of two near-infrared detectors — discrete amplification Avalanche Photodiodes — on the lower end of the 1-meter diameter Nickel telescope at Lick Observatory on Mount Hamilton east of San Jose, California, and run the system through a series of engineering checks.

The project is a collaboration of the University of California at San Diego; U.C. Berkeley; the University of Toronto; the SETI Institute in Mountain View, California; and the University of California's Lick Observatory.

SETI experts have long been anxious to search for infrared signals.

"We had to wait another 20 years, until we had detectors that would make infrared SETI feasible. Our team has been testing these new infrared detectors for the last several years, and we are now ready to point them at the sky," Wright said. "This is essential to the future of SETI programs…to be able to use brand new detectors and take advantage of communication technology development."

"It could be a breakthrough," Drake suggests, but he offers a caveat to the forthcoming SETI activity. "It does depend on the extraterrestrials helping you out by targeting you. The stellar beams are so narrow that they have to be aimed precisely," he said.

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Iridium picks 4 firms for sat terminals

To expand its presence in the growing market to transmit data to and from airliner cockpits, Iridium Communications has selected four avionics and electronics companies to design, manufacture and sell satellite terminals compatible with Iridium Certus, the high-speed broadband service Iridium plans to introduce in late 2016 with its Iridium Next constellation.

Iridium, based in McLean, Virginia, will authorize Cobham Satcom, a business unit of Britain's Cobham plc, Rockwell Collins of Cedar Rapids, Iowa, L-3 Communications of New York, and International Communications Group of Newport News, Virginia, to create a variety of Iridium Certus products for aviation and maritime markets.

Iridium plans to give its new partners great flexibility in product designs. They may opt, for example, to produce satellite terminals with flat, beam-steering antennas or with more traditional and lower-cost antenna technology. "We are not just going to build a box and see if people can resell it," says Iridium Chief Executive Matt Desch. "We are going to provide core technology to allow partners room for innovation."

Although Iridium has played a far larger role in maritime communications in the past, heightened demand by air carriers and corporate aviators for information to improve aircraft performance and trim operating costs is prompting Iridium to redouble its focus on the aviation market.

"We intend to have a network you can rely upon for 100 percent global coverage with products certified for aviation," Desch said in an interview. "We plan to offer a broadband service that can serve operational requirements in the cockpit in a very reliable way."

Iridium is scheduled to begin launching spacecraft in October into its Iridium Next constellation of 66 low-Earth orbit satellites designed to offer more bandwidth and higher data speeds than the firm's original constellation established in 1998. When the Iridium Next constellation is complete in 2017, customers will have data speeds as high as 1.4 megabits per second, Desch says.

Through Iridium Certus, flight crews will be able to communicate with air traffic controllers in addition to receive frequent updates on weather conditions, turbulence, aircraft operations and maintenance issues. "There are probably more than 100 data applications that are being contemplated today," says Brian Pemberton, Iridium Communications director of aeronautical and maritime product management. "With the higher speeds we will provide with Iridium Certus, that number probably will grow several fold."

Iridium selected its new partners both for their research, development and manufacturing acumen as well as their established distribution networks. "We picked big, well-known players to build a whole portfolio of solutions that can be sold in the marketplace not just by themselves, but by other firms that we will announce later this year," Desch says. "I think we'll make a big impact on aviation as we bring these products forward in the next two to three years."

Debra Werner
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Four companies will design and build satellite terminals for the Iridium Next constellation.

Iridium Communications



In Europe, pushback on defense tech spending

Attendees at the June meeting of the European Council in Brussels are expected to discuss options for maintaining adequate spending on defense research and technology in Europe.

The European Union doesn't have a defense budget of its own, but representatives to the body have warned that a decline in defense research spending by member countries poses security and economic challenges for Europe. Total spending on defense research and technology by European governments fell 15 per cent between 2006 and 2013, according to the latest figures from the Brussels-based European Defense Agency.



European Defence Agency

Defense technology advocates in Europe want cooperative research in such areas as rotorcraft.

Last June, the European Commission, the union's executive body, developed a plan to increase the amount spent on defense research by accessing some of the union funds allocated for civil research. The commission's 2014-2020 research program — called Horizon 2020 — is budgeted at around 80 billion euros ($89 billion).

The commission is a civil agency with no responsibility for defense policy, which is decided by national governments of the union's 28 member states. So Horizon 2020 funds can only be spent on civil research. But under the commission's proposals, Horizon 2020 funds could be allocated to projects that support the European Union's common security and defense policy goals in areas such as peacekeeping, anti-insurgency operations, surveillance, cyber defense and other security programs that do not stray too far from the defense arena.

The idea of applying some Horizon 2020 funds in this way had high-leveling backing when Horizon 2020 was released in January 2014: "It is clear that developing and maintaining the technology and critical capabilities required for the future is beyond the capacity of individual Member States. While defense and security remain primarily a matter of national responsibility, more can be done [by the European Union] to promote European co-operation," said the then-commissioner for internal market and services Michel Barnier, in a news release issued at the launch of the plan in 2014. He has since been replaced by Elżbieta Bieńkowska, Poland's former minister of regional development.

A recent think tank analysis concludes that key governments in Europe are likely to stay the course on defense spending. "There is little sign of a significant shift in Europe's long-term downward trend in defense expenditure, despite concerns over Russian behaviour and developments in the Middle East," said a study from the European Leadership Network titled "The Wales Pledge Revisited: A Preliminary Analysis of 2015 Budget Decisions in NATO Member States," and published at the start of 2015. "None of the NATO countries examined have the funding or the domestic support to fully modernise their militaries and comprehensively develop their individual defense capacity. More defense cooperation among allies is the only realistic way forward."

The study concludes that cooperation among European countries might be the most promising way for European states to maintain indigenous defense capabilities. Other evidence, however, suggests that boosting spending on cooperative endeavors could prove elusive. Overall defense spending on research and development among EU members totaled 7.5 billion euros ($8.4 billion) in 2013, according to figures from the European Defense Agency. More than 84 percent of that money was spent nationally rather than on cooperative programs. There is little evidence that most governments would prefer to work with their neighbors on joint programs rather than retain control over strategic defense research programs.

The spending contrast with the United States is also stark in terms of research and development. The U.S. Defense Department spent $63 billion on R&D in 2014. Most of Europe's spending also goes to the civil side: According to figures on the AeroSpace and Defense Industries Association of Europe website, total aeronautical research and development reached 20 billion euros in 2013: 16 billion euros on civil aeronautics and 4 billion euros for defense programs.

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European militaries cut costs on helicopter training with new methods



Improving helicopter training has been a feature of the 'Hot Blade' exercises conducted by the European Defence Agency.

European Defence Agency

As many European defense forces face the grim prospect of shrinking budgets amid an increasing number of military operations, they are finding that traditional training methods using helicopters no longer suffice. Instead, many countries have developed interactive training devices and procedures using low-cost technologies along with higher levels of cooperation.

The kinds of missions that the continent's militaries are being asked to perform — peacekeeping, humanitarian aid, medical evacuation and anti-insurgency, among others — are on the rise but training is becoming more expensive. Realistic training must take place in cooperation with allies and in a variety of environments. Because full-mission helicopter simulators cost anywhere up to $20 million, simply buying more simulators to meet demand is no longer realistic.

French Army aviation training centers have over the past several years been equipped with the Helicopter Mission Trainer, known as EDITH in the French Army, a low-cost multiplatform device developed by Thales that provides a synthetic environment for aircrew tactical training. In November and December 2014, the Aozou military exercises linked the mission trainers at Phalsbourg and Etain for the first time in French Army training. Simulation centers 150 kilometers (94 miles) apart were linked over a secure network and the trainers integrated into the operational information system. This enabled tactical commanders to share the same operational picture. Commanders were presented with over 30 separate helicopters in the series of exercises; some were "live" platforms and some were simulated but were able to coordinate their operations regardless of the physical status of the assets.

Another approach to tactical crew training has been made available to Swedish, Czech and Hungarian support helicopter aircrews, for whom the European Defence Agency (EDA) in Brussels has developed a cost-effective training aid with the help of AgustaWestland. Delivered within a year for less than 400,000 euros ($454,000), including the first training course, the simulator was based on Microsoft's Flight Simulator software and provided training for the rear crew as well as offering cockpit personnel the ability to train and rehearse such procedures as the "breakaway maneuver," an effective countermeasure against unexpected ground fire.

Over the last five years, the EDA has developed and carried out a series of live, collaborative, multinational helicopter exercises under the designation "Hot Blade," which combined a wide range of helicopter applications ranging from tactical reconnaissance to air assault and hostage rescue. Multinational training can help smaller nations gain access to facilities and experience that would otherwise be out of their reach, according to Andrew Gray, the EDA's helicopters program manager.

"By pooling expensive assets but also sharing hard-won knowledge, we can give Member States the opportunity to attend large-scale exercises that would otherwise be unaffordable," Gray said in an email. "This is an approach we have been implementing since 2009, and so far more than 300 European helicopter crews have benefitted from this collaborative training."

In another effort at new training efforts, the United Kingdom's Joint Helicopter Command in early February took delivery of the first of two trainers for Puma and Merlin helicopter operations, intended to provide embarkation, disembarkation and emergency egress training for troops using the medium support helicopters.

The $330,000 contract was won by Lutra Associates, a consortium of independent consultants, in partnership with Oxford Specialist Coachbuilders. The trainers are housed in modified cargo containers and have been designed to be moved to wherever the training is required. This allows the command and the Royal Air Force to save money as they re-allocate aircraft to more operational tasks while improving training for the troops.

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Coming soon: ESA's full account of IXV flight



A Vega rocket carrying the experimental spaceplane IXV lifts from Europe's Spaceport in Kourou, French Guiana, on Feb. 11.

European Space Agency

Detailed mission results from the February flight of the unmanned Intermediate Experimental Vehicle spaceplane are to be announced by the European Space Agency by June 15.

Those results will indicate how the craft's thermal protection and other systems held up. For now, the craft's landing west of the Galapagos Islands in the Pacific Ocean looks like a high mark in ESA's long-term plan to build a relatively low-cost reusable vehicle that can fly to various orbits, operate missions such as servicing satellites or conducting microgravity experiments, and return them to Earth by landing on a runway.

The IXV reached an altitude of 412 kilometers and a top speed during descent of 7.5 kilometers per second before coming down 40 minutes after launch just as planned, according to ESA. It was then taken to Genoa in Italy for more detailed study of the mission results.

The craft and mission were funded by the European Space Agency and built by Thales Alenia Space of Italy. It is the size of an automobile, weighs nearly 2 tons and is 5 meters (16 feet) long.

The vehicle has a lifting body shape — meaning it produced lift without wings — and is equipped with a complex outer thermal protection layer and an advanced inner composite structure that divides the vehicle into four bays, ESA fact sheets state. The lifting body configuration was selected after a comparison of performance trade-offs and was designed from experience gained with the ESA's Atmospheric Reentry Experimental Vehicle and the French government's Centre National d'Etudes Spatiales' PRE-X reusable atmospheric re-entry concepts.

Critical technologies tested included the overall design, some complex new materials and an innovative flight management system.

New ceramics matrix composites were used on the nose, shingles, hinges and flaps, and ablatives such as cork and silicon-based materials were used on the vehicle's leeward surfaces. The IXV automatically controlled flight through a combination of thrusters and flaps, using guidance algorithms obtained through the coupling of inertial measurements and GPS.

The IXV is the second of three vehicles planned by ESA to master the key technologies for shuttle-like operations. First came the Advanced Reentry Demonstrator mission launched on the third flight of the Ariane 5 in October 1998, then the IXV and now agency scientists are working on the follow-on project — the Programme for Reusable In-orbit Demonstrator in Europe, or PRIDE.

"In my opinion, the most significant technical success [of the IXV] is to be seen in the demonstrated capability of Europe to integrate a number of on-the-edge re-entry technologies into a flying vehicle," Roberto Provera, director of Human Spaceflights and Transportation Programs at Thales Alenia Space, said in an email. "The capability to master aerothermodynamics, advanced shape (lifting body), thermal protection system, guidance, navigation and control, and to harmonize them into a reliable system is the basis for the future PRIDE."

PRIDE is being developed as an orbital platform to test multiple applications such as future reusable launchers stages, Earth observation, robotic exploration, microgravity experimentation and transport of crew and cargo to and from the International Space Station. ESA says the PRIDE space plane would be comparable — albeit smaller, cheaper and under civilian management — to the U.S. Air Force's X-37B.

One of the key design criteria for both the IXV and PRIDE is affordability: The IXV mission (excluding the cost of the launcher) cost 150 million euros ($167 million) and PRIDE mission costs are targeted at 200 million euros. The go-ahead for PRIDE was approved at the ESA's Ministerial Conference in December 2014 and the mission is most likely to take place in 2019 or 2020, according to an agency press officer.

"Thanks to the data collected during the flight, we are paving the way for the development of new-generation re-entry vehicles in Europe," Elisio Prette, president and chief executive officer of Thales Alenia Space Italia, said in a news release.

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Sikorsky

Wingtips on the blade of a CH-53K helicopter have inverted winglets, shown up close, that help diffuse tip vortices and also help hover performance.

Know your winglets

by Nathan Wasserman
nathanw@aiaa.org

Southwest Airlines released a television commercial in 2013 describing how winglets or "do-hickeys," as the narrator calls them, save over 54 million gallons of fuel a year and help the airline charge just $69 for a one-way fare. With my interest piqued, I did a bit of reading and learned that winglets are designed to reduce drag-inducing wingtip vortices and add a little more lift. This increases an aircraft's lift-to-drag ratio. In fact, I read in Air & Space Smithsonian and the Chicago Tribune that winglets can reduce drag by as much as 20 percent and fuel consumption up to 5 percent. With winglets now on my radar, I looked out for them whenever I went to the airport for a flight

I didn't expect to learn more about winglets when I postponed my senior year at the University of Maryland to begin a 12-month internship at Sikorsky's main facility in Stratford, Connecticut, under a cooperative arrangement with my university. During a tour of the plant, I saw a rotor blade being prepared for final assembly. The blade had what looked like an inverted winglet on the tip. I made it a priority to learn the purpose of this design before I finished my co-op.

I spoke to one of Sikorsky's lead engineers for blade design and we spent a few minutes discussing the design process for the rotor blade wingtips of the CH-53K heavy-lift helicopter. The tip's anhedral, or downward angle, planform cuts down on the vortices coming off the wing to ameliorate drag. Weaker vortices mean less vibration, which means less noise originating from the turning blades. The reduced vibrations produce a more efficient aircraft and make flying easier for the pilots. This type of blade tip design is also used on Sikorsky's Black Hawk and S-92 helicopters. On the 53K, the anhedral bend and other wingtip specifications maximize lift/hover capabilities. Although the winglet on a 737 has an upward deflection, it has a similar purpose: increase lift on the wing.

Once I returned to the University of Maryland, I went to see Professor Inderjit Chopra. Later, he explained by email that on helicopters: "Winglets can normally hurt performance in forward flight...however, a small winglet can help to diffuse tip vortices that can minimize noise and may also help hover performance."

Looking back, I realize that understanding this design choice required me to draw on formal pedagogical resources — notes from my classes, including aerodynamics 1 and 2 — and also discussions with leaders in the industry about Sikorsky's 2009 patent for a rotor blade tip planform (see US7513750). Oftentimes, it is easy to get frustrated spending four months learning a subject only to think you might never discuss it again. My experience at Sikorsky gave me a greater appreciation for my education. I feel confident that among my notes, textbooks and professors I will be able to come up with a reasonable understanding of any technology. Being a very visual learner, a real world situation — such as encountering a CH-53K rotor blade — helps me maximize my grasp of a concept.

✈✈✈

Aerospace engineering student Nathan Wasserman is a senior at the University of Maryland and an Alexander R. Norris Space View intern at AIAA.

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Modeling heat off rocket engines

NASA needs to be sure the nozzles and heat shields of its new Space Launch System rockets will be able to handle the heat generated during liftoff and ascent. Henry Kenyon explains how engineers at Marshall Space Flight Center are turning to new tools and some Shuttle-era ones to measure the effects of the complicated heat flows that will envelope an SLS on every launch.

When NASA's Space Launch System heavy lift rocket roars into orbit in 2018 it will be the largest, most powerful launch vehicle ever flown by the space agency, able to haul up to 143 tons into orbit or launch an Orion crew capsule beyond low-Earth orbit. To get all this into space, the first stage of the SLS will rely on four liquid-fuel RS-25 rocket engines and two solid-fuel booster rockets, generating tremendous amounts of potentially dangerous heat around the vehicle's propulsion area.

By using a combination of scale models, sensors and analysis tools, engineers at NASA's Marshall Space Flight Center in Huntsville, Alabama, are working to ensure that the thermal protection systems in the rocket's lower, or base, area won't fail due to heat-related damage during launch and ascent.

The space agency hasn't designed a launch vehicle like the SLS since the Space Shuttle in the 1970s. Lack of in-house knowledge forced the Marshall team to relearn old techniques, such as the building of scale rocket models to test base heating. But this process also allowed the use of new tools unavailable to previous generations of engineers, such as fluid computational dynamics to model heat flows, laser spectrometry and high-speed infrared cameras to study engine plumes, and new heat-resistant materials to build the test models' engine nozzles. This suite of tools and expertise could also be applied to develop new generations of spacecraft and planetary exploration probes.

All multi-engine rockets experience base heating during launch. This combination of convection (air and hot exhaust gases) and radiation (heat from the exhaust plumes) affects the lower half of the launch vehicle. This heating is dynamic, changing in intensity and location during the various stages of ascent as atmospheric pressure drops.

Four distinct base heating phases take place during a launch, explains Mark Seaford, an engineer with Marshall's SLS Base Heating Program. The first occurs at low altitude at the start of the launch. Here, the individual rocket engine plumes are separate and air naturally flows across and down the rocket's base, cooling it. Phase two occurs at intermediate altitudes where the jet of air moving across the base competes with an updraft jet created by the interaction of multiple rocket plumes, such as those on the SLS. Base heating remains relatively low at this stage, he says.

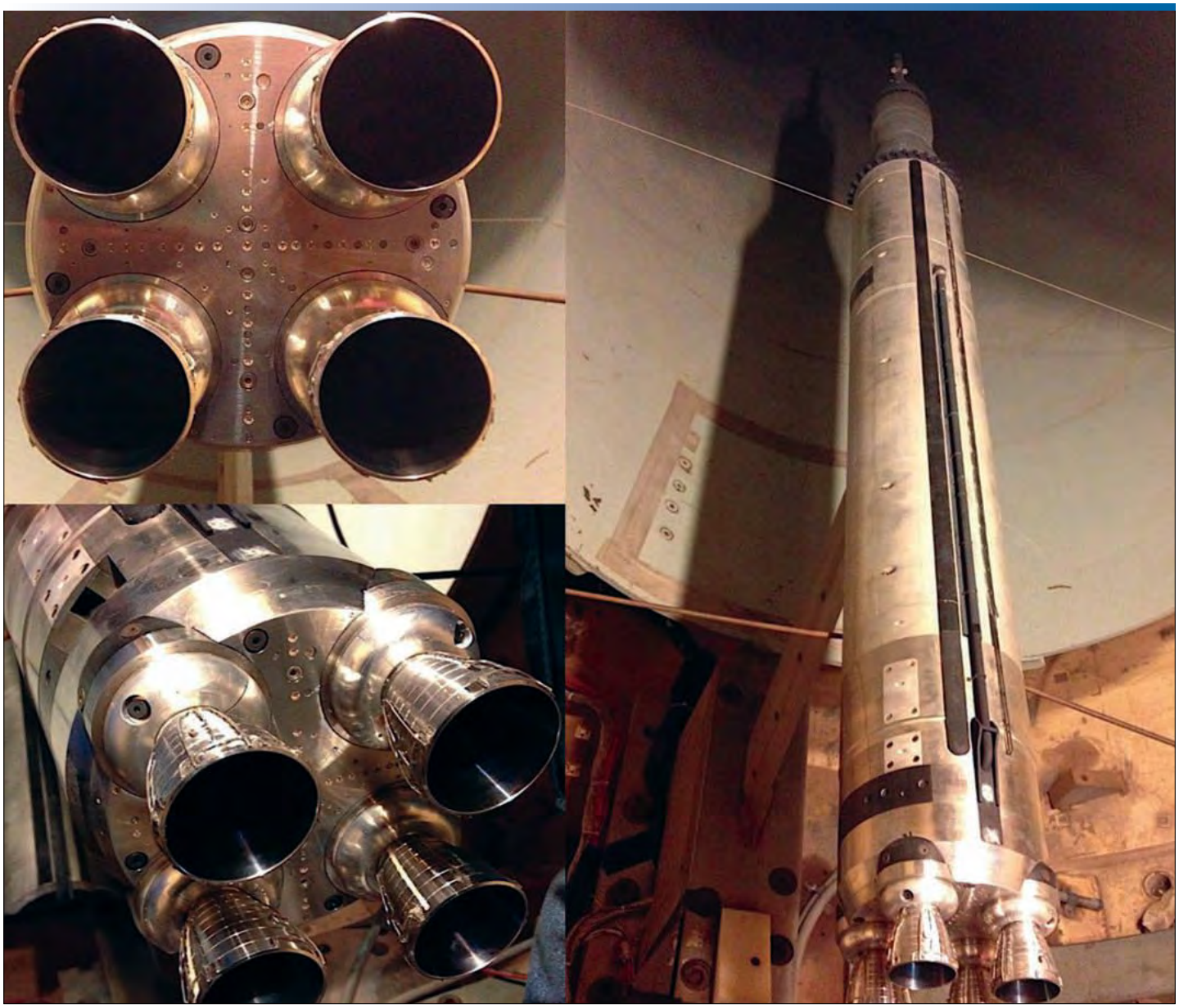
Maximum base heating takes place at high altitudes where the different rocket plumes expand and combine into a single plume because of low atmospheric pressure. The airflow over the base decreases and hot exhaust gases come into contact with the rocket's base plate, which leads to peak temperatures, Seaford says. Temperatures plateau during the fourth stage as the rocket reaches the edge of space. Here the engine plumes remain combined and hot gases recirculate around the rocket's base.

Understanding how that heat travels and ensuring that heat shielding and dissipation techniques are working properly is vital to avoid the formation of dangerous hot spots. Improper base heating mitigation led to a string of rocket explosions in the 1950s. Using scale models to test rockets for base heating also dates from this period. The first models were developed in the late 1950s to help better understand and solve heating issues for the Saturn rocket program, explains Manish Mehta, the Base Heating Program's lead engineer.

Subscale models

To test the SLS design's base heating dynamics, NASA engineers, working with CUBRC Inc. — a research, testing and systems integration company based in Buffalo — built several functional subscale test models. Manufactured to 2 percent scale, the models are 6.5 feet long with a base diameter of 6 inches without the solid rocket motors. The booster rockets add an additional 6 inches to the model's diameter, Mehta says. Instead of liquid oxygen, the model's simulated R-25 engines burn a combination of gaseous oxygen and hydrogen while the solid rocket boosters use solid fuel.

The models are tested in an 8-foot



NASA/Marshall Space Flight Center

Model rockets: NASA is using miniature Space Launch System rockets to understand the heat patterns that will be produced by the new rocket's RS-25 engines. This 6.5-foot-tall model is located at contractor CUBRC's facility in Buffalo.

diameter shock tunnel at CUBRC's LENS II facility in Buffalo. Shock tunnels simulate and model a rocket's transition from sub- to supersonic speeds. These tunnel tests are short, lasting only 50 to 150 milliseconds. The engines fire briefly to reduce the amount of heat to which the hardware (especially the engine nozzle throats) is exposed. This is because heat flux — the amount of heat transferred through a surface or material — is inversely proportional to the radius of the engine nozzle's throat, Seaford says. In a small-scale model, the heat flux is much higher than in a full-scale flight engine. Additionally, unlike a full-scale system, there is no active cooling of the nozzles, so short durations test runs prevent damage to the model.

"You can't run it very long or else you'll get a burn through," he explains.

One of the initial challenges in running such tests was that the last time they were run was for the Space Shuttle program. "It's been 40-plus years since we've designed such a propulsion system for short-duration testing and much of the corporate knowledge went away with it," Mehta says. The program's initial phase was to train its young engineers in the model testing process and develop new models.

A major hurdle was designing model engine motors that performed like full-scale engines. Seaford notes that the model engines used in the Shuttle-era tests ran at pressures that were 50 percent less than the projected engine pressure of the full-scale system. This contrasts with the SLS models that run at 80 percent of expected operational pressures. The engineering team was able to gather data in 40-millisecond windows during testing — about twice as long as

the data similar Shuttle-era tests were able to collect, Seaford says.

Better diagnostic tools

The NASA team also benefits from technologies that previous base heating efforts did not have, such as advanced diagnostics tools to create sophisticated models of engine exhaust plume flow fields as they pass different Mach speeds and altitudes with varying air density, says Aaron Dufrene, technical lead at CUBRC.

Tunable diode absorption laser spectroscopy allows engineers to study the gas temperature in a rocket's exhaust plume as it interacts with the base of the vehicle. This is the first time the non-intrusive laser diagnostic system has been used in a base heating test program, Mehta says. This is critical to verifying SLS base thermal environments to properly size the rocket's thermal protection system, he adds.

Other important tools that were previously unavailable are high-speed mid- and long-wave infrared cameras to view engine exhaust plumes. Mehta notes that much of a rocket's plume cannot be seen with the naked eye during ascent. But infrared cameras provide engineers with insight into the physics of exhaust plume dynamics. The infrared cameras used by NASA are capable of capturing 10 to 20 infrared images during a multimillisecond test. Such imagery was not available in the past and offers a better means to understand base air and gas flows, according to Mehta.

The SLS base heating team also took advantage of new materials to make the model's rocket engine nozzles more heat-resistant than older test models, like those used in the Shuttle program. Some of the materials are resistant to high temperatures and resilient to thermal shock — when different parts of an object, such as a heat shield or rocket nozzle, expand at different rates.

After a brief hiatus in February, the Base Heating team plans to kick off another round of tests. So far, ascent tests have been completed, covering performance at altitudes of 70,000 to 195,000 feet. Additional tests will cover "engine out" scenarios in which an engine fails to ignite or stops during launch as well as simulating additional rocket stages.

Besides supporting the SLS efforts, Mehta notes that NASA now has an in-house capability and expertise to evaluate and model spacecraft rocket plume environments. Other applications for this process include developing future launch systems for NASA, the Defense Department or private industry; modeling more powerful versions of the SLS boosters; and developing planetary landers and studying liftoff/plume environments.

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NASA's bid to grab an asteroid – 9 things to know

The Asteroid Redirect Mission, or ARM, is the only human deep space mission on NASA's planning horizon, but the proposal faces deep skepticism among some in Congress. With the budget season in full swing, planetary scientist and former astronaut Tom Jones examines the ARM proposal, its political prospects and the stakes of cancellation.

ARM is two missions in one >>

ARM consists of two components: a robotic asteroid capture mission to nudge the object into lunar orbit, and a later astronaut sortie to visit and sample the asteroid. The Asteroid Redirect Vehicle is the robotic craft planned for launch between 2019 and 2021. It will nab a small asteroid or, alternatively, pluck a boulder off a larger one and deliver the object to lunar orbit. ARM would open the way to dissecting and exploiting hundreds of tons of ancient rock, potentially rich in water, organic compounds and metals — feedstock that could jump-start in-space propellant production and asteroid mining.

As of mid-March, NASA was closing in on a decision about a preferred asteroid retrieval technique for ARM. Option A proposes to snare a freely orbiting, 7-meter near-Earth asteroid by enclosing it in an inflatable, fabric capture bag. Option B would send the redirect vehicle to the surface of a larger, well-characterized near-Earth asteroid (easier to detect and determine the object's composition) and retrieve a multi-ton boulder for return to the Earth-moon system.

An interim step to "deeper space" missions >>

With the NASA budget driving the first piloted mission of the Orion/Space Launch System combination out to 2021, the White House realized in 2012 that NASA wouldn't be able to send astronauts to a near-Earth asteroid in its native orbit by 2025, a goal set by President Barack Obama two years earlier. So the White House and NASA shifted course and acted on a study showing that within a decade astronauts could visit a small asteroid nudged into lunar orbit. Sending astronauts to the captured asteroid would be an interim step toward future deep-space operations at the moon, more distant asteroids and Mars. ARM would follow the 2021 Space Launch System/Orion flight test as NASA's next (and currently only) piloted deep-space mission. The mission would technically meet the Obama administration's goal of getting humans to an asteroid by 2025.

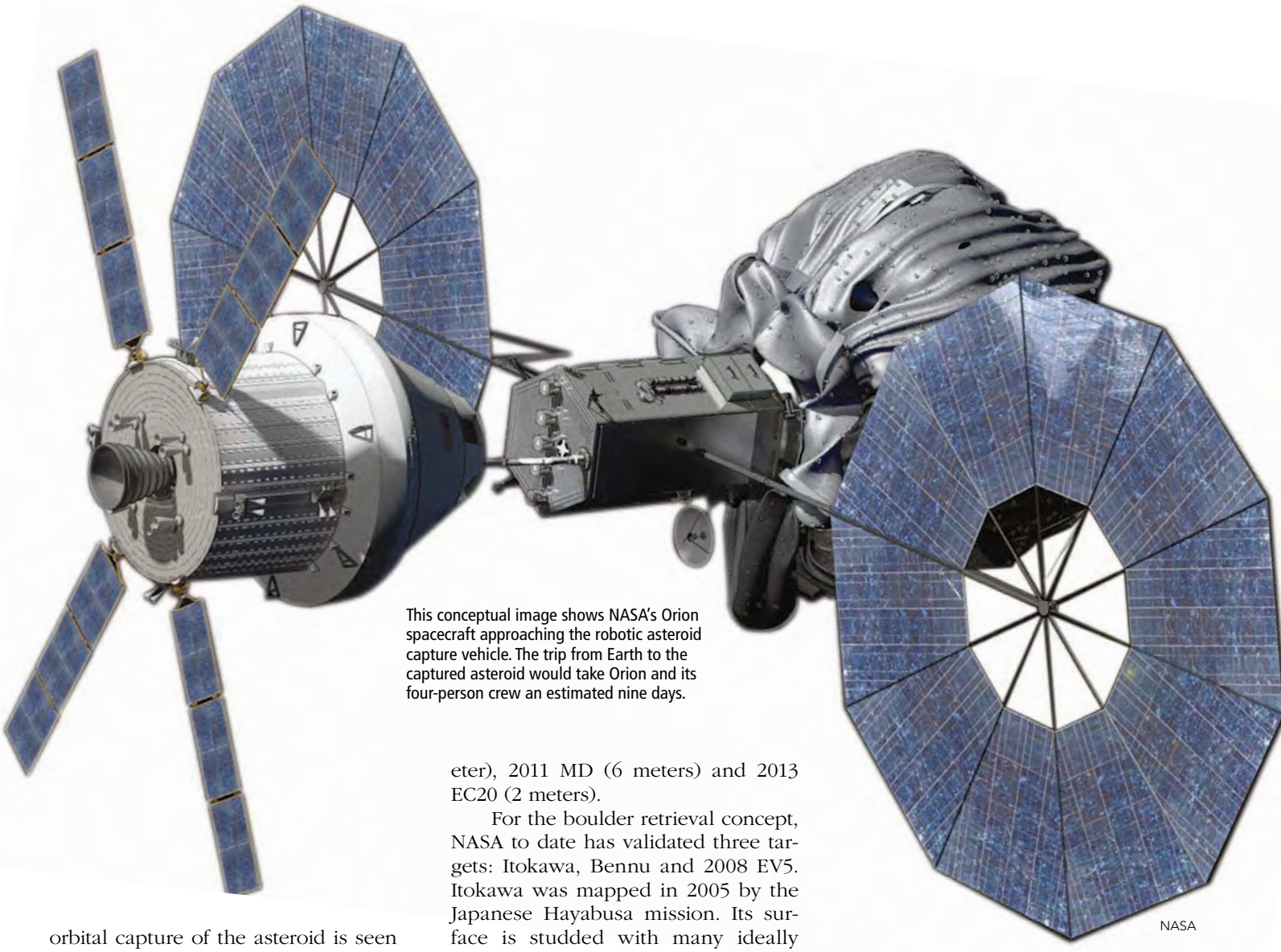
Ground testing the retrieval options >>

Last year, NASA built a 1/5-scale Asteroid Capture Testbed at Jet Propulsion Lab for Option A, the proposal to engulf and move an entire asteroid to lunar orbit. NASA engineers tested the capture bag's deployment sequence, moved it over a mocked-up asteroid, and measured the forces on the bag's fabric as it retracted around the rotating asteroid.

For Option B — plucking a boulder from a larger near-Earth asteroid — Langley Research Center in Virginia last year employed a full-scale robot arm testbed to simulate gripping a boulder, subjected the arms and landing legs to the forces required to "lift" a surface boulder, and ran closed-loop simulations of descent, surface and ascent operations. These tests show that the redirect vehicle's sensors can meet landing accuracy requirements and that the retrieval spacecraft can sustain the loads predicted for a wide range of asteroid surfaces and boulder masses.

The agency would prefer to capture and redirect a small near-Earth asteroid with a mass up to 500 tons (Option A), but those asteroids are the toughest to detect and characterize (estimate its mineral composition, links to known meteorites, shape, spin rate, etc.). Ideally, NASA would like to redirect a water- and organic-rich object for its scientific and resource potential.

If an attractive, approximately 7-meter asteroid cannot be identified in time for a launch around 2019, or if



This conceptual image shows NASA's Orion spacecraft approaching the robotic asteroid capture vehicle. The trip from Earth to the captured asteroid would take Orion and its four-person crew an estimated nine days.

NASA

orbital capture of the asteroid is seen as too technically risky, NASA is protecting Option B: robotically landing on a larger (thus brighter and easier to characterize) asteroid, and returning a multi-ton boulder to the Earth-moon system. Landing, boulder retrieval and departure pose difficult engineering challenges, but Option B offers the return of tens of tons of the "right kind" of asteroid material. For example, NASA might return a boulder from the well-studied 550-meter diameter 25143 Itokawa asteroid. But Itokawa is known to lack the water and organic material preferred for ARM targets.

NASA has target candidates in mind >>

NASA's three valid candidates so far for Option A — capturing an entire asteroid — are 2009 BD (4-meter diameter), 2011 MD (6 meters) and 2013 EC20 (2 meters).

For the boulder retrieval concept, NASA to date has validated three targets: Itokawa, Bennu and 2008 EV5. Itokawa was mapped in 2005 by the Japanese Hayabusa mission. Its surface is studded with many ideally sized boulders roughly 3 meters across. Radar observations of both 2008 EV5 and Bennu suggest that both near-Earth asteroids possess appropriate-sized boulders. NASA will probably not choose its final asteroid target until a year before the Asteroid Redirect Vehicle launch, circa 2019. NASA would like to identify a slate of candidates, each approximately 7 meters in diameter with a mass of 500 tons. Spotting small objects like these is a difficult challenge for ground-based telescopes, but NASA estimates it will find three to five suitable candidates annually between now and 2019. No new candidates were found in the last half of 2014.

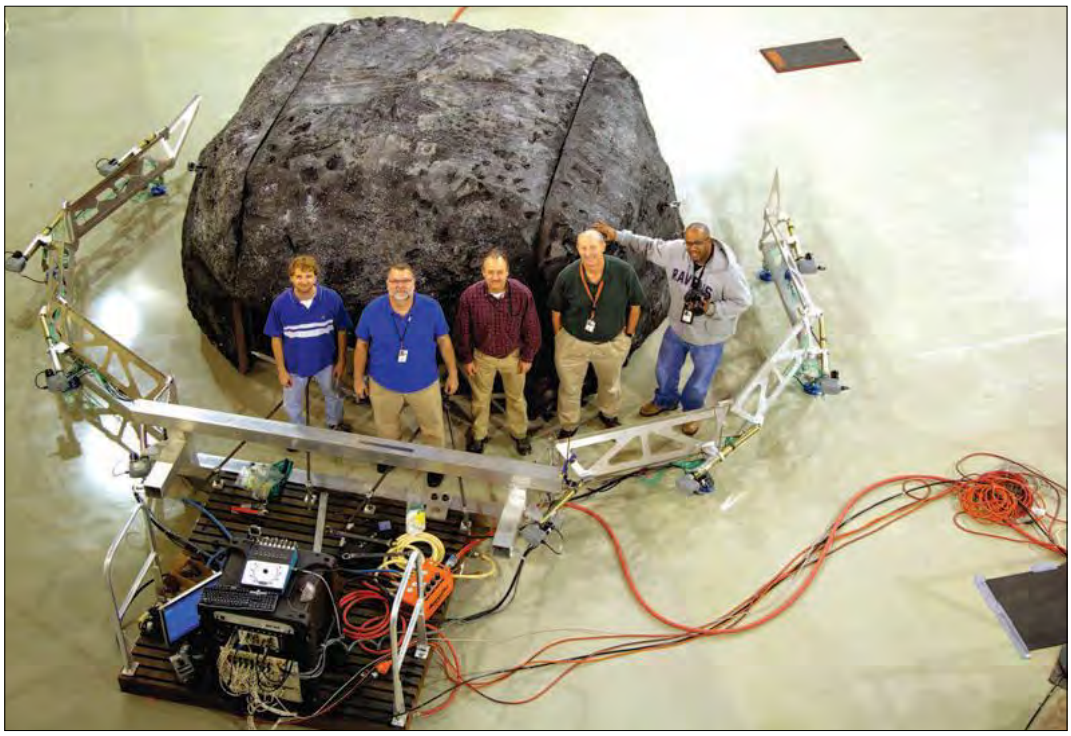
Scientists recommend that NASA choose a previously unexplored near-Earth asteroid with a composition rich in water and prebiotic organic materials, similar to carbonaceous chondrite meteorites. A carbonaceous asteroid also offers the highest commercial potential, particularly for water extraction demonstrations. Water can furnish oxygen and hydrogen for propellant, provide oxygen for life support and serve as efficient radiation shielding.

Growing cancellation risk >>

NASA requests $220 million for ARM in the fiscal 2016 budget. Funding for the redirect vehicle would need to ramp up sharply by 2017 to meet a 2019 launch date, an increase that depends on NASA convincing Congress that ARM is a wise choice. NASA wants to launch the retrieval

vehicle between 2019 and 2021, with the date depending on how long it takes to develop the vehicle and which target is selected. Orion astronaut sorties would be conducted between 2023 and 2027.

With members of Congress likely to question ARM funding, the robotic capture craft's 2019-2021 launch window is in serious jeopardy. Because the robotic mission can take up to four years to rendezvous with, capture, and redirect an asteroid into lunar orbit, the follow-on astronaut visit would also be delayed. NASA is concerned that prolonged ARM delays risk outright cancellation by Congress or the next administration.



NASA

Option B test: NASA engineers at Langley Research Center used an air-bearing floor to gauge how well a pair of full-scale robot arms can grasp and extract a simulated asteroid boulder; plucking a boulder is one capture option.

Congressional skepticism runs deep >>

The Obama administration's decision to rule out the Bush return to the moon and revamp human spaceflight policy continues to stir opposition in Congress. Cancellation of the Constellation rocket and crew vehicle program in February 2010 earned the ire of Sen. Richard Shelby, R-Alabama, and Rep. Lamar Smith, R-Texas, whose states are home to NASA's Marshall Space Flight Center and Johnson Space Center, respectively. Smith criticized ARM in an op-ed soon after it was announced, writing that the country needs a goal "worthy of a great space-faring nation," and ARM "is not it."

Some in Congress oppose ARM simply because its asteroid focus ignores the nearby, accessible moon. The Obama administration has directed NASA managers to not pursue lunar exploration as a human spaceflight option. Others reject NASA's contention that ARM will help advance Mars exploration.

The link between ARM tech and a human Mars mission >>

In response, NASA is trying to rally congressional support by reporting progress in its ARM technology testing and by detailing how ARM feeds into Mars exploration plans. NASA argues that ARM will deliver tested hardware and invaluable experience that will smooth the path toward Mars. Solar electric propulsion, capable of redirecting hundreds of tons of near-Earth asteroid mass during ARM, can deliver large cargoes, such as surface elements, propellant and astronaut habitats, to Mars or its moons, Phobos and Deimos.

Deep space rendezvous, complex orbital maneuvers into and out of planetary gravity wells, and extended deep-space extravehicular activities are part of the complex robotic and human deep-space operations necessary for projected Mars expeditions.

For example, ARM experience in proximity and surface operations in low gravity fields, anchoring and surface sampling in near freefall, and emplacement of surface equipment can all be applied to the exploration of Phobos or Deimos.

At NASA's fiscal 2016 budget briefing in early February, NASA Administrator Charles Bolden said technologies developed for ARM "will be applicable to commercial satellite servicing, future exploration, resource extraction, mining, in situ resource utilization and planetary sample return…and will demonstrate advanced high-power Solar Electric Propulsion, critical for future NASA and commercial uses."

NASA still has some convincing to do. Bolden discussed ARM with NASA's Advisory Council on January 14; Council member and retired aerospace executive Thomas Young flatly responded: "Proving that we can redirect an asteroid has nothing to do with going to Mars."

Critics have few good alternatives >>

President Obama said in a 2010 speech at Kennedy Space Center that "by 2025, we expect new spacecraft designed for long journeys to allow us to begin the first-ever crewed missions beyond the Moon into deep space."



A big lift: A half-buried "boulder" is extracted from a simulated near-Earth asteroid in a test at Kennedy Space Center. The test rig allows designers to estimate the force required to retrieve a boulder from a larger asteroid in Option B of the Asteroid Redirect Mission.

NASA Kennedy Space Center Swampworks

Yet the White House's outyear budgets do not include funds for a spacecraft capable of multimonth journeys into deep space (Orion is limited to one-month missions). With no projected capability to reach a near-Earth asteroid in solar orbit, NASA adopted ARM, putting a small asteroid within reach of Orion. Barred from even studying the design of a human-capable moon lander, NASA sees ARM as the only near-term initiative that will materially advance its human spaceflight capabilities. If American astronauts visit such an asteroid in a retrograde lunar orbit, the United States will have sent humans farther into space than any nation in history — with hopes of expanding that capability toward Mars.

Some in Congress have bolder ambitions for NASA, but those plans are hamstrung by NASA's projected budget, even with a proposed increase to $18.5 billion. Because the Obama administration will not acquiesce to a rewrite of its human spaceflight policy or a wholesale reallocation of NASA's budget, the most Congress can do is reprogram funds to accelerate the advent of Orion and the Space Launch System. While Congress and NASA wait for the next presidential administration to arrive with a new round of "expert" recommendations, the only practical piloted deep-space mission the agency can advance is ARM.

Cancellation would erode U.S. human space program >>

If ARM is canceled, NASA with current funding could do little more with the Space Launch System and Orion than fly astronauts around the moon or visit empty Lagrange points in the Sun-Earth or Earth-moon system — this while China orbits a station and lands astronauts on the moon. If the International Space Station is decommissioned in the mid-2020s, the U.S. will also have ceded low-Earth orbit activity to other nations, and to exclusive commercial tourism operators. ARM is a stopgap and child of necessity, but if successful, should be a springboard to more ambitious deep space expeditions. If canceled, its demise might well signal NASA's decision to abandon human space exploration altogether.

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U.S. Navy

On a human mission, a crew might need to wait about two hours for a Navy team to free them from the Orion capsule. The crew can escape through side or top hatches, if necessary. Here, a recovery team arrives at the unmanned version of Orion that splashed down in December.

The

Orion capsules will take astronauts out of low-Earth orbit for the first time since the Apollo missions. The dangers can't be taken lightly. Debra Werner explains what NASA and Lockheed Martin are doing to keep astronauts safe, and more comfortable, inside the capsule.

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human factor

by Debra Werner

An hour before the space shuttle orbiter Atlantis carved its way back into the atmosphere at the end of a 2002 mission, astronaut Lee Morin downed 48 ounces of chicken soup to ward off any lightheadedness or fainting that might be produced by high G-loads. Space shuttle crews routinely took that precaution, known as fluid loading, because the ride subjected them to peak levels of about 2.5 times Earth's gravitational force during re-entry.

Astronauts traveling on NASA's next manned mission beyond low Earth orbit, slated for around 2021, are in for a rougher ride. They'll experience 4.5 to 5 Gs during re-entry of the Orion multipurpose crew vehicles because the trip back from deep space produces higher re-entry velocity and heat loads than shuttle's return from low Earth orbit. Plus, parachutes drop space capsules onto water with more force than winged vehicles experience during a runway landing.

NASA and Lockheed Martin have designed Orion so that the four crew members will be in a reclined position with their feet above them during the capsule's ascent and descent, which means the higher G-forces are not likely to produce any loss of consciousness. Still, Orion's crew members are likely to follow the NASA tradition of chugging chicken soup as a precaution against buffeting or any contingency operations that produce more force than expected, says Morin, who works in the astronaut office at Johnson Space Center, Houston, helping to design Orion's cockpit.

NASA and prime contractor Lockheed Martin have been developing Orion with astronauts in mind since 2006 when the company won an $8 billion contract to build the spacecraft. In spite of extensive modeling and simulation, no one knew how well the spacecraft would protect astronauts from extreme temperatures, radiation and micrometeorites until a Delta 4 Heavy rocket lifted off on Dec. 5 carrying an early version of Orion packed with instruments in lieu of a crew. Now that all the data is in, "we think the ride is going to be pretty comfortable," Morin says.

Keeping cool

The Exploration Flight Test 1 (EFT-1) version of Orion hurtled home at speeds approaching 20,000 miles per hour. Just as planned, about 20 percent of its heat shield, consisting mainly of a foamlike material known as Avcoat, melted and vaporized when its surface temperature reached nearly 4,000 degrees Fahrenheit, according to sensors mounted in the heatshield. That ablation helped dissipate lots of heat, but the exterior of the capsule was still piping hot at splashdown—the heatshield temperature varied between 140 and 220 degrees Fahrenheit and the backshell temperatures varied between 100 and 120 degrees Fahrenheit.



An early version of an Orion capsule launches from Kennedy Space Center, Florida, on Dec. 5, 2014, atop a Delta 4 Heavy rocket for a two-orbit, four-hour flight that tested many of the systems most critical to safety. Orion crews in future years are expected to explore asteroids, among other missions.

NASA

"We were concerned that when we landed, heat energy would radiate back into the capsule," Mike Hawes, Lockheed Martin vice president and Orion program manager, told reporters during a Feb. 18 briefing. "That would be extraordinarily uncomfortable for the crew."

On an actual mission, a crew might have to wait about two hours for a Navy crew to arrive, longer in an emergency splashdown. If needed, the crew can get out before the Navy arrives by opening the capsule's heavy side hatch with an explosive charge or climbing out a small hatch on top of the capsule.

To find out if a crew would be safe and comfortable during the wait, Lockheed Martin recorded temperatures inside the crew cabin for an hour after the splashdown 600 miles south of San Diego.

Orion's heat shield combined with the spacecraft's evaporative ammonia cooling system, which circulates ammonia throughout the crew cabin and around electronic boxes, keeps the temperature in the crew cabin at 77 degrees or lower during the hour after its water landing.

Astronauts aboard Orion would be wearing heavy spacesuits, so for added comfort they'll be able to control the amount of cold water pumped through their Spandex undergarments, which look like long underwear crisscrossed by IV tubes. Astronauts working outside the International Space Station rely on the same cooling garments.

Radiation exposure

Once Orion leaves Earth's orbit, its crews and electronics will be bombarded by galactic cosmic radiation and solar winds of varying intensity. Rather than trying to design the entire capsule to block what could be a rare radiation spike from a solar flare, engineers devised 42-inch by 25-inch by 28-inch aluminum lockers behind each crew member's seat. Clothes, cameras and flight equipment will be stored in these lockers, but NASA would alert the astronauts when ground-based telescopes and satellite sensors spot unusual solar activity.

"They would remove components from the lockers and hook them to various points around the crew cabin because all of the hardware helps absorb radiation," says Lockheed Martin's Blaine Brown, the crew module deputy director. "Then they



NASA

Spacesuit engineers demonstrate how the four crew members would be arranged for launch inside the Orion spacecraft. NASA and Lockheeed Martin have designed Orion so that crew members will be in a reclined position with their feet above them during the capsule's ascent and descent, preventing loss of consciousness from the higher G-forces.

would climb into the lockers, which are a little safe haven."

Apollo, Shuttle and ISS had lockers. Orion's are different because they are integrated with the primary structure in the aft bay of the capsule to maximize use of available volume. The lockers used by astronauts aboard the Apollo missions were not designed to protect the crew during a large solar radiation event. And because the Shuttle and International Space Station operate in low Earth orbit, they benefit from the Earth's magnetic field shielding, so their exposure is not as risky as deep space exploration, and their lockers aren't designed for that purpose.

Orion astronauts would have plenty of incentive to cram into the tight space. Since exposure to high levels of radiation can increase a person's risk of developing cancer, NASA keeps close tabs on how much radiation astronauts encounter. The agency bans them from space missions when doctors determine their U.S. government work has increased their risk of getting cancer in their lifetime by 3 percent compared with the population at large.

"Your career is over as an astronaut when you hit that level of exposure," says Morin, whose own radiation exposure included his medical work on a U.S. Navy nuclear submarine.

During EFT-1, officials at mission control in Houston monitored radiation levels with battery-operated detectors developed by NASA Johnson and the University of Houston. "From the measurements we made, everything stayed within the expected range," according to Hawes. [NASA and Lockheed Martin are not yet ready to offer detailed information on Orion radiation levels recorded in the crew cabin but may be after they submit the report on EFT-1 to NASA, which was scheduled for March 5.]

Aside from the threat to astronauts' health, deep space radiation can jeopardize the performance of the computers and communications equipment, causing data corruption, locking up processors or damaging spacecraft electronics. The capsule's walls made of an aluminum-lithium alloy will block some radiation, but the electronics will have to keep running through levels higher than experienced by electronics in low Earth orbit, which are protected to a degree by the Earth's magnetosphere. NASA and Lockheed Martin monitored those systems closely during EFT-1.

Orion's avionics computers continued to function even though EFT-1 took the spacecraft through the Van Allen Belts, regions of charged particles trapped by Earth's magnetic field. "We flew through one of the worst radiation environments

Seats to save the spine

Astronauts are in for quite a jolt when the Orion multipurpose crew vehicle splashes down. The spacecraft's parachutes are designed to slow the space capsule from 480 kilometers (300 miles) per hour in the upper atmosphere to less than 30 kilometers per hour at impact.

To prevent injury, NASA and Orion prime contractor Lockheed Martin are working with Safe Inc., a company based in Tempe, Arizona, that is known for producing energy-absorbing helicopter seats. Orion will be equipped with crew seats that slide a few inches along the axis of the astronaut's spine.

"When Orion hits the water, there will be forces in several different directions," says Tony Herrmann, subsystems manager for the Orion Crew Impact Attenuation System in NASA Glenn Research Center's Crew Service Module Mechanisms Group. "The human body is pretty resilient except the spine. You don't want spines to be compressed."

Initially, NASA and Lockheed Martin tried to reduce the force of impact by mounting each astronaut's seat to a pallet below using seven struts to absorb energy in different directions. Data retrieved during Orion's Exploration Flight Test-1 on Dec. 5 proved that NASA could simplify the design and reduce weight by replacing the struts with metal that slides a few inches along a single axis.

It's not yet clear what metal Safe Inc. will use in the new design. NASA gave the company its crew protection requirements and Safe Inc. will determine the best way to develop the system, Herrmann says.

"It turns out we did not need struts going in every direction," Herrmann says. "We just needed them going in one direction to prevent spinal injury."

The new Orion Crew Impact Attenuation System is expected to weigh less than 18 kilograms (40 pounds) per seat, compared with roughly 64 kilograms for the previous design, Herrmann says.

The Orion space capsule's mass is limited to 20,500 pounds by the parachutes used to slow its descent in Earth's atmosphere. Because of that ceiling, NASA and Lockheed Martin are searching for ways to reduce mass to make room for additional flight equipment.

Debra Werner

and the system performed exactly as designed," says Paul Anderson, Lockheed Martin's Orion avionics director.

Before the flight, Orion engineers screened parts to eliminate ones that could be damaged permanently by radiation. They also took the bold step of relying on commercial processors instead of radiation-hardened processors, which often slow computations. To make up for any vulnerability, Lockheed Martin worked with Honeywell International to equip the spacecraft with pairs of computers designed to monitor each other and correct problems.

"The fantastic surprise was how well that operated," Anderson says. "There were some events that caused upsets as expected, but the system self-corrected."

A bigger test will come during Orion's Exploration Mission-1, when the spacecraft spends 21 days in a distant retrograde orbit near the moon.

Micrometeorites

Orion also must protect crews from micrometeorites. Even a tiny pinprick could cause the air inside the capsule to rush out into the vacuum of space. During Orion's initial flight, micrometeorites struck the spacecraft and penetrated its thermal protection system but stopped before reaching the crew cabin just as the spacecraft's engineers expected, says Jim Bray, Lockheed's Orion crew module director.

Orion's exterior tiles absorbed the first strike of micrometeorites, slowing their velocity. Debris created by micrometeorites then passed through the tiles and spread out in the air gap between the tiles and the crew module, where the spacecraft's computers and cables are housed. The exterior of the crew module, which is composed of an aluminum-lithium alloy, then absorbed the smaller, slower debris particles.

"Since Apollo, we have learned that protection from radiation and micrometeorite debris is critical, especially for long duration missions," Bray says. "Apollo was designed for seven-day missions. Our requirement is for 21 days. We are going to be out there longer and need to survive greater radiation and greater exposure to micrometeorites."

Comforts of home

For any journey beyond 21 days, Orion would need to be linked to a larger service module packed with food, equipment and supplies. For shorter missions, Orion is designed to afford more comfort and privacy than Apollo. Apollo capsules offered 70 cubic feet of habitable volume per person, compared with Orion's 78 cubic feet or about twice the passenger volume of a Ford Explorer. Lockheed Martin seeks to use every bit of that space.

After ascent, Orion's seats fold down, which helps make room for many of the amenities Apollo did not have, including a water dispenser, food warmer, toilet, exercise equipment and a small curtained area where astronauts can change clothes privately or take a sponge bath.

"Apollo was designed to go to one place and its mission duration was



NASA

Heat shield: As expected, about 20 percent of Orion's Avcoat shielding melted and vaporized during re-entry in December. NASA experts inspected the shield after it arrived at Marshall Space Flight Center in Alabama.

known," Bray says. "We've got to be able to accommodate any destination for ranges much longer than Apollo did. Having access for the crew to be able to be safe, to be able to be hygienic, and to be able to live, eat and breathe is what we are about."

Flight crews

NASA does not plan to select astronauts for Orion's first manned flight until about two years before takeoff. Nevertheless, 20 astronauts already are becoming familiar with the spacecraft through extensive flight simulation exercises. Every couple of months, two astronauts, one commander and one pilot, come to Building 9, the Vehicle Mockup Facility at Johnson Space Center, to fly in a static simulator.

The astronauts don flight suits, gloves, headsets and spend approximately four hours going through various flight scenarios, including most recently an ascent full of problems. "We take them through countdown and launch," Morin says. "They see the displays and respond to the malfunctions."

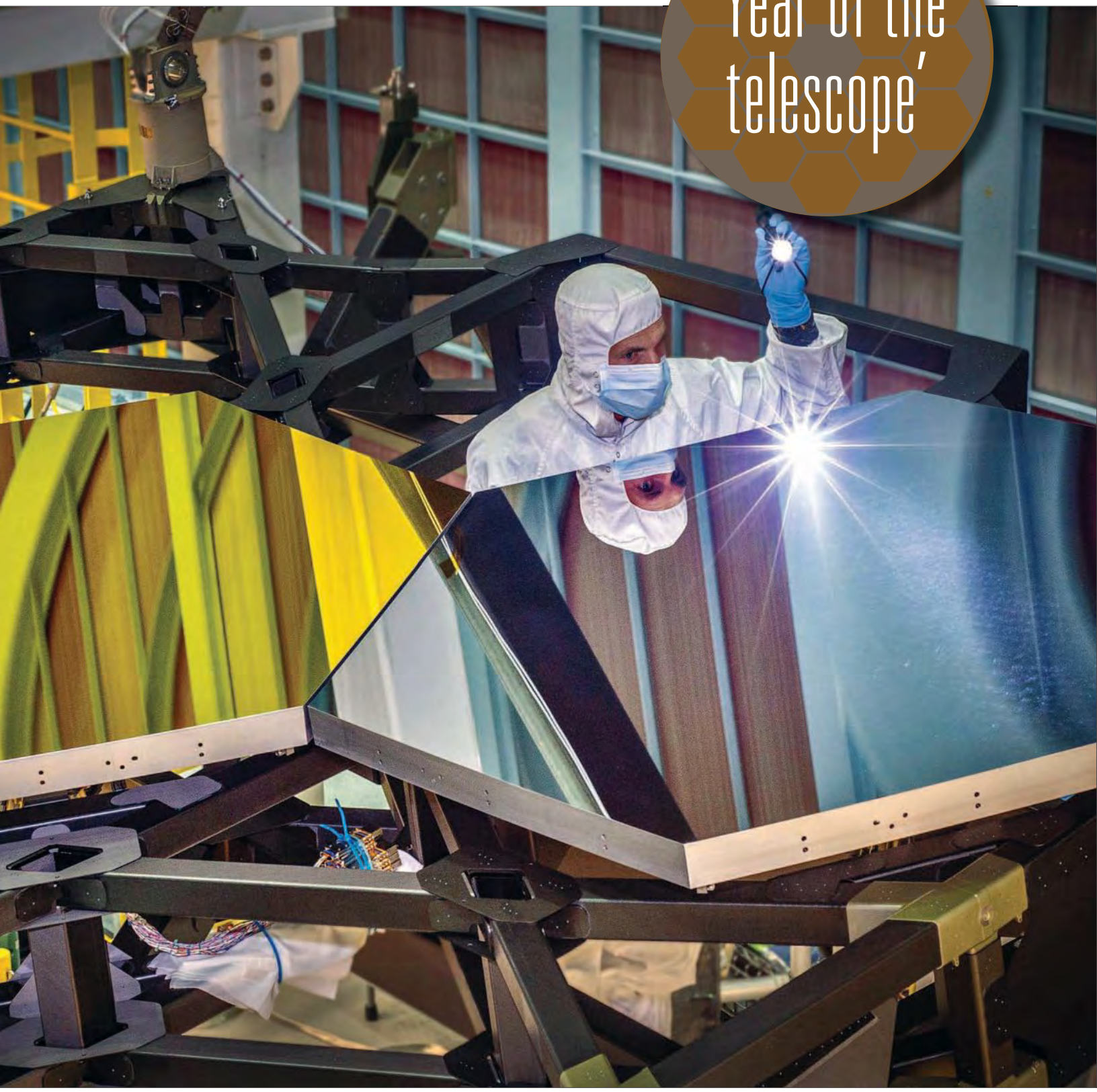
One hallmark of NASA's astronaut training program is its ability to test how well prospective flight crews tackle problems and stressful situations. About two years before Morin was selected for his 2002 Space Shuttle mission, he and five colleagues spent 10 days in a tent in Northern Canada's Arctic region. NASA mission control gave them assignments, which included early frequent treks into the Arctic night and temperatures as low as 30 degrees below zero Fahrenheit.

"They would give us map coordinates and send us five miles to get essential supplies," Morin says. "The essential supplies were a case of frozen broccoli to go with the case of frozen broccoli they had us get at 3 o'clock in the morning the day before. Or they would ask us to observe some stars and take readings, but the stars weren't visible from the Northern Hemisphere."

This type of expedition, like much of astronaut training, is designed to test a person's response to exhaustion, stress and discomfort. No matter how well-designed Orion is, spending seven days journeying to the Moon or 21 days investigating an asteroid will mean leaving behind the comforts of home.

That type of hardship doesn't deter them, Morin says. "Getting the privilege of riding on Orion, being in deep space for the first time since the 1970s, perhaps rendezvousing with an asteroid or being on the way to the moon or Mars, people are prepared to put up with a little discomfort for that." ▲

'Year of the telescope'



NASA

Pathfinder: An optical engineer at NASA's Goddard Space Flight Center in Maryland examines two test mirror segments attached to a composite backplane like the one that will hold the 18 segments of the James Webb Space Telescope's primary mirror. The Pathfinder telescope will be tested with the same equipment and processes as the flight telescope.

by Ben Iannotta

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NASA is pushing development of the Webb telescope into a critical assembly and test phase at a time when investigators at the Government Accountability Office warn there is little room left for error. Ben Iannotta visited Goddard Space Flight Center to learn how NASA plans to surprise the doubters and get Webb into space with no further delays.

Like high-tech eggs waiting to hatch, two rows of metallic silver containers are perched on a mezzanine at NASA's Goddard Space Flight Center in Maryland. The containers overlook the same cleanroom where more than two decades ago the Hubble Space Telescope's corrective optics were prepared. The containers hold an equally precious cargo: mirror segments due for assembly this year into the optical element of the James Webb Space Telescope.

Once Webb reaches space, these 18 segments must automatically align themselves to form a 6.5-meter diameter primary mirror smooth to 100 nanometers, or about a thousandth of the width of a human hair, says NASA's Lee Feinberg, manager of Webb's Optical Telescope Element.

That's just one feat in what will be a weeks-long series of automated set-up procedures as Webb coasts to its orbit beyond the moon. Feinberg has agreed to brief me about the turning point his team has reached in development of Webb telescope and show me around Goddard's Building 29, where he has worked since the run-up to the 1993 Hubble repair mission.

The Government Accountability Office describes Webb as "one of the most complex projects in the National Aeronautics and Space Administration's history," and the GAO's characterization is not an overstatement.

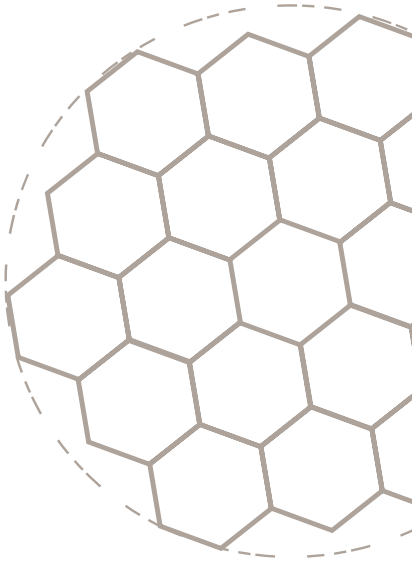
Webb looks nothing like Hubble or any other telescope, because it's meant to do something that's never been done before: Look back in time 13.5 billion years toward the first light of the universe to see the birth of stars and formation of planets. That means detecting light that's been stretched to infrared wavelengths by the expanding universe. Most of Webb's technical challenges spring from the need to keep the optics and science instruments cold, so that those infrared waves aren't swamped by warmth from Webb. A tennis court-sized sunshield must keep the optics at minus 370 degrees Fahrenheit. That's cold, but not as chilly as required by Webb's Mid-Infrared Instrument, one of the four science instruments that will be attached in a module behind Webb's primary mirror. The MIRI instrument will need a helium cooling system to keep it at minus 449 degrees, just 10 degrees shy of absolute zero, so it can detect mid-infrared wavelengths.

Building Webb has turned out to be a lot harder and time-consuming than expected. Today's projected cost of $8.8 billion is nearly double a 2009 estimate, and GAO says the cost has actually ballooned by a factor of nine if one looks at the original cost estimates of astronomers. Webb was going to be launched in 2014, but NASA now plans to launch it in October 2018 on an Ariane 5 rocket contributed by the European Space Agency.

Over the next three years, Feinberg and managers at NASA's Jet Propulsion Lab, Johnson Space Center, Northrop Grumman and Exelis must do more than assemble and rigorously test all elements of a unique space telescope. They must orchestrate a story of redemption, one that could convince future presidents and skeptical lawmakers that this first-of-a-kind telescope should not be the last of its kind. Within decades, astronomers want to launch an even more fantastic telescope with a mirror diameter three times that of Webb's for a range of astronomy, including possibly photographing an Earthlike exoplanet for the first time.

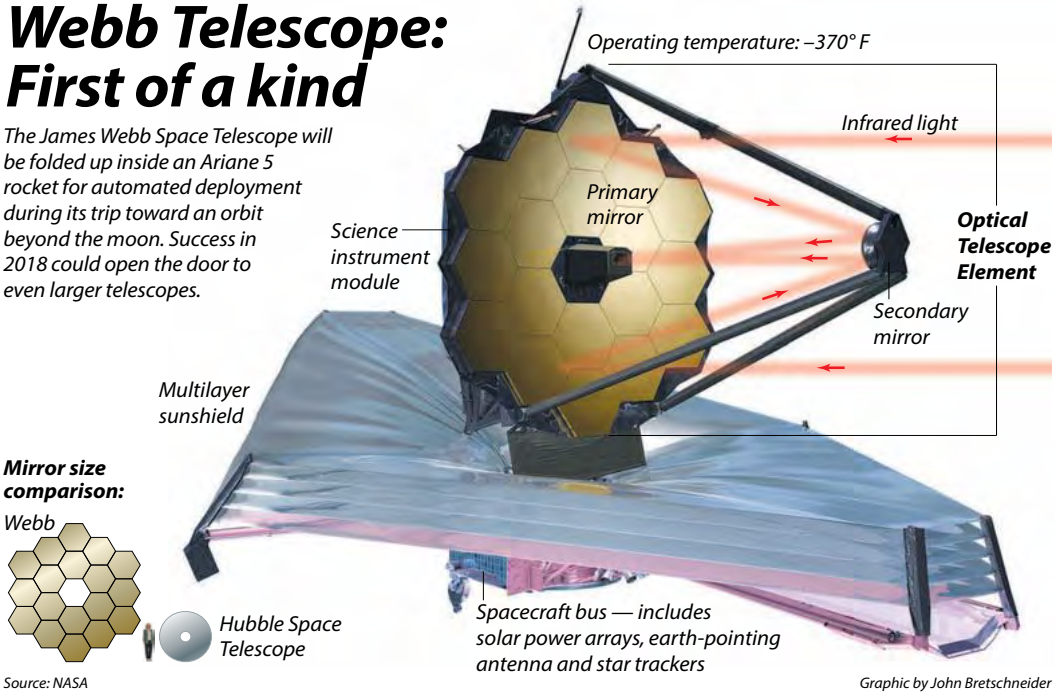
"If the country was smart and NASA wants to do it, we could leverage all this [Webb] stuff to build future bigger telescopes," says Feinberg.

But first, things are about to get busy in Building 29.



Webb Telescope: First of a kind

The James Webb Space Telescope will be folded up inside an Ariane 5 rocket for automated deployment during its trip toward an orbit beyond the moon. Success in 2018 could open the door to even larger telescopes.



Source: NASA

Graphic by John Bretschneider

'Year of the telescope'

Technicians will soon take the mirror containers down from the mezzanine and open them for the first time since 2012, and four years since L-3's Tinsley Lab in Richmond, California, finished polishing the mirror segments.

"We're going to have a telescope in a little under a year from now," Feinberg says. "A full, built-up flight telescope, right in this clean room." Eric Smith, Webb's program scientist and acting program director at NASA headquarters, has dubbed 2015 "the year of the telescope."

The mirrors will be rigorously inspected and installed by Exelis onto a graphite composite backplane structure that's due to arrive in August from Northrop Grumman. Three thousands miles away, managers at NASA JPL in Pasadena, California, will be shepherding the Northrop-supplied cryocooler for the Mid-Infrared Instrument to completion. On top of that, replacement detectors for Webb's near-infrared instruments still need to be fully tested in a cryogenic vacuum chamber at Goddard, after a flaw was discovered in 2010 with the first batch. The Integrated Science Instrument Module, which will carry Webb's science instruments behind the optics, is due for a third test later this year.

"There's this amazing race going on between ISIM, the Integrated Science Instrument Module, team and the Optical Telescope Element team," Feinberg says. ISIM needs to be ready for installation on the telescope early next year.

Concurrent work is the name of the game even within Feinberg's portion of the program. While assembly of the flight mirror is underway at Goddard, a Pathfinder telescope consisting of a backplane with two mirror segments will be tested inside Vacuum Chamber A at Johnson Space Center. It was trucked from Goddard late one night to Joint Base Andrews in Maryland and flown to Houston on an Air Force C-5C cargo plane. The idea of the Pathfinder is to iron out any assembly or test issues. Chamber A is the same chamber where NASA tested the Apollo hardware, but NASA had to upgrade the chamber to simulate the incredibly cold operating conditions for Webb. Engineers want to put the Pathfinder through it before they fly the flight telescope to Houston and roll it into the chamber in 2016.

Webb managers are confident that no Hubble-scale flaw — a primary mirror manufactured to the wrong prescription — lurks in their mirrors. The mirrors were tested multiple times during years of manufacturing at Ball Aerospace in Colorado, at Tinsley Lab and at NASA's X-Ray and Cryogenics Facility in Huntsville, Alabama. In Chamber A, the team will be "turning the temperature down on [the Pathfinder], getting it cold, not just making sure that we can put light through it, but that the chamber's working," explains Scott Willoughby, Northrop's program manager for Webb.

Testing everything, even the test equipment, is a key part of the Webb strategy. "You don't want to build, build, build…and then test at the end," Willoughby says. "For a program like Webb, you do a lot of additional testing at each step of the way because that's the best place to find anything you need to resolve."

Mystery of the yellow flakes

Here at Goddard, Feinberg shows me an example of the kinds of problems that can be caught by running a Pathfinder through the same processes and facilities that the flight telescope will go through, right down to the elevator the mirror segments will ride in and the hallway they'll be wheeled down. We're deep in the bowels of Building 29, peering into to a cleanroom called the C-I-A-F, for Calibration, Integration and Alignment Facility. Each flight mirror segment will go through this room to make sure its shape has been maintained before it is assembled onto the backplane.

When the pathfinder mirrors were in the C-I-A-F, a technician spotted yellow particles on them. The flakes turned out to be bits of paint from a new crane and cabling installed in the room. The crane was painted incorrectly, "so when the crane operated, it generated yellow particles," Feinberg explains. "We figured out a way to cover the mirrors during Pathfinder, and said 'OK, once Pathfinder's done, we'll go back, we'll pull the cable off. We'll clean it up.' "

If the crane problem had come up with the flight mirrors this year, in theory it could have eaten up some of Webb's schedule reserve, the extra time that NASA requires program managers to distribute throughout construction timelines for large projects like Webb. GAO, which now reviews Webb's status annually on orders of congressional appropriators, warned in December that this reserve is down to 11 months, with critical work left, including fully testing the new detectors and finishing the cryocooler for the Mid-Infrared Instrument.

Much of the Webb plan involves testing, and Feinberg says managers carefully weighed the need for so much of it when they conceived the program. Hot on their minds was that a Hubble-style repair mission would be out of the question for Webb, which will coast beyond the moon to an orbit around the second Lagrange point, one of the locations in space where a spacecraft can orbit with relatively little energy. L2 is behind Earth relative to the sun, so Webb will be able to avoid warmth and stray light from the Earth and sun. NASA wants to get human explorers into deep space, and technologists say astronauts might someday help assemble a giant telescope. None of that could be ready in time to help a wounded Webb.



The mirrors of the James Webb Space Telescope shown in their shipping canisters at NASA's Goddard Space Flight Center in Maryland. Each of the 18 primary mirror segments is made of beryllium, which was selected mostly for its stability at cold temperatures.

As an example of Webb's complexity, Feinberg tells me to consider the motorized actuators attached to the mirror mounts on the back of each segment. Six on each segment will control the segment's position relative to the others. A seventh in the center will impart a force to keep the segment correctly curved, so the segments perform like a giant monolithic mirror. An electric motor and gears in the actuators must adjust the positions in steps of just 10 nanometers, which works out to one ten-thousandth of the width of a human hair. That's how the mirrors will be aligned to an accuracy of a thousandth of the width of human hair.

"Could you have imagined if we'd gotten to L2, we deployed the mirrors and we didn't have enough actuator stroke to get the system aligned?" Feinberg says.

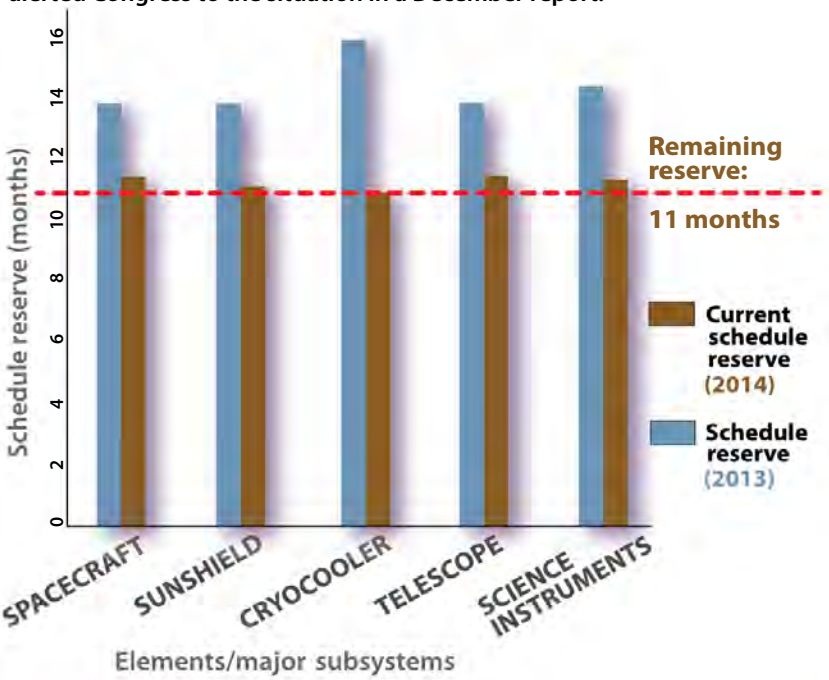
Tests, and lots of them, were put into the plan.

Ripple effects

Webb managers are still feeling the impact of a technical issue discovered with Webb's near-infrared detectors in 2010. These detectors, made of mercury cadmium telluride, convert infrared light into electricity and ultimately astronomical observations.

Shrinking Schedule Reserve

NASA requires managers of complex projects to program in time for the unexpected. Webb managers say they are dipping into this reserve at a reasonable pace. The Government Accountability Office nevertheless alerted Congress to the situation in a December report.



Source: GAO analysis of NASA data, GAO-15-100

They are at the heart of Webb's Near-Infrared Camera, Near-Infrared Spectrograph and Near-Infrared Imager and Slitless Spectrograh and the co-located Fine Guidance Sensor, the device that will keep Webb precisely pointed at its science targets.

The Defense Department was using the same kind of detectors in 2010, and it alerted NASA to a problem with them. "They were sensitive enough, but over time that sensitivity would degrade because of something in the way that the detectors were manufactured," says Smith, the acting Webb director.

NASA decided to stay with the manufacturer, Teledyne Imaging Sensors of Camarillo, California. "It was recognized [that] all they had to do was change their process in a small way, rather than [NASA] go out and get a whole other vendor," Smith says. Qualifying a new vendor's detector for flight would have been too time-consuming and "That would have been a much more costly route," Smith adds.

The rub was that it would take several years for Teledyne to produce new detectors. NASA couldn't risk waiting that long to begin testing the Integrated Science Instrument Module in a cryogenic vacuum chamber, so it conducted two tests without all of the required detectors and added a third test to the plan. CV3, as its known, will test the new detectors on all the instruments for the first time later this year.

The GAO is worried about the timing of all this, noting in its December report that the Integrated Science Instrument Module has burned through three months of schedule reserve out of the 7.5 months it had in 2013.

Another big challenge has been the cryocooler for the Mid-Infrared Instrument, or MIRI. A cryocooler consists of a compressor to pressurize helium and a cold head to chill the sensor with the helium. Northrop explains that conventional cryocoolers have compressors and cold heads "sitting right next to the instrument to be cooled."

That design was not possible with MIRI because of limited room in the instrument module and the need to minimize vibrations that could hurt the telescope's performance and insulate the instruments from warmth that could overwhelm the infrared light. Designers decided to put the compressor on the sunward side of the sunshield and push helium coolant through a line that will run through the shield and up the telescoping tower that holds the optical assembly above the sunshield, a distance of about 30 feet. Northrop says it had to develop new manufacturing techniques and test processes for the cooler.

"We've proven the physics, and now we're building and testing the flight hardware," Northrop says. All the flight equipment should be delivered "in the middle of 2015." NASA chimed in with a statement saying the cold head has been delivered and attached to the instrument module, and that all the electronics have been delivered. NASA is waiting for the compressor assembly to be delivered to JPL for testing.

What does all this mean? For believers like Feinberg it suggests that redemption could be within reach. "Before the first [Hubble] servicing mission, it was like NASA's credibility was on the line," he tells me. "But after that thing got up there and worked, it was like all the sudden there was a complete sea change. And I feel like that's what's going to happen here. Where else is there this level of exploration and discovery on our planet?"


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BRINGING CHINA INTO THE SPACE FOLD

THE AGENDA BEHIND U.S.–CHINA SPACE RELATIONS



ANALYSIS
by Marco Cáceres

Over the past four years, NASA has been looking for ways to cooperate with China in space. When NASA Administrator Charles Bolden testified before the U.S. House Foreign Affairs subcommittee on oversight and investigation, in November 2011, he said. "Some level of engagement with China in space-related areas in the future can form the basis for dialogue and cooperation in a manner that is consistent with the national interests of both our countries, when based on the principles of transparency, reciprocity, and mutual benefit."

Bolden delivered his remarks only three days after the China National Space Administration launched its Shenzhou 8 unmanned capsule to low earth orbit and docked it with the Tiangong 1 module, launched weeks earlier. The docking was an historic mission for the Chinese space program, because it marked the first major step toward realizing China's vision of constructing its own orbiting space station.

Bolden had led a U.S. delegation to China in 2010, to "explore areas of mutual interest," but it wasn't until after Shenzhou 8 that one sensed a shift taking place — one in which the U.S. was starting to regard China as a legitimate competitor in space. Shenzhou 8 was a wake-up call not too dissimilar from the launch of the Sputnik 1 satellite by the Soviet Union in 1957. It con-

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China might not be an enemy of the U.S., but it's definitely a competitor. Faced with an increasingly active Chinese space program, the U.S. has adopted a "keep your competitor close" strategy. Teal Group analyst Marco Cáceres examines China's space breakthroughs of recent years, and the U.S. reactions to them.

DLR

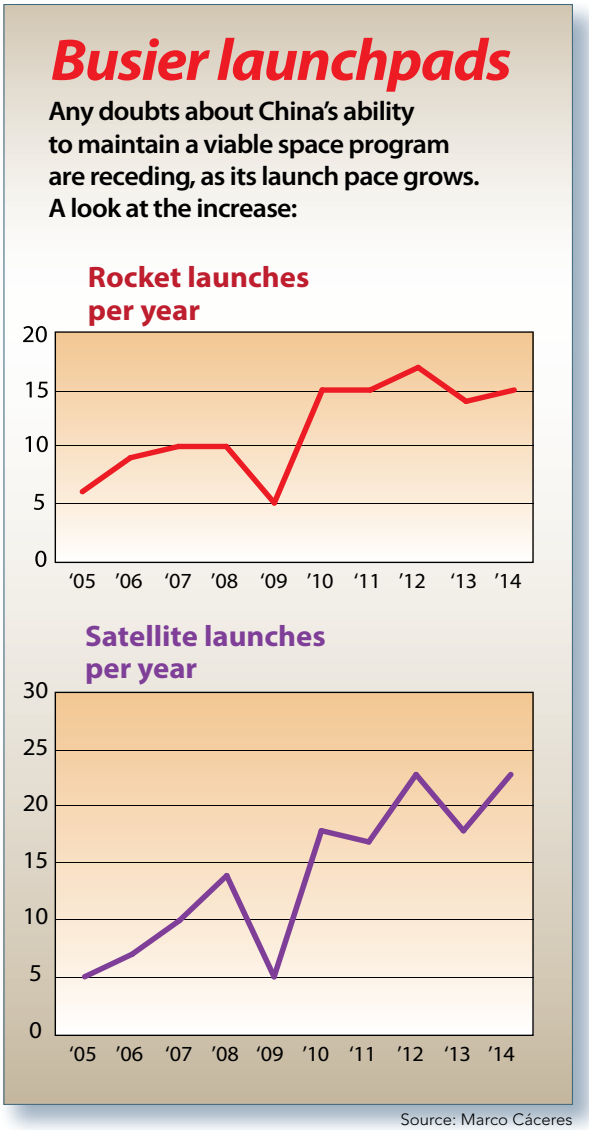
A Long March 2F rocket carrying China's Shenzhou 8 was rolled out in 2011 at the Jiuquan Satellite Center.

firmed that the Chinese were serious about building a space station and maintaining a permanent presence in space.

It was followed by more China successes. A crew of three docked to the Tiangong 1 module in June 2012, marking the first manned docking by China. The mission commander later entered the Tiangong 1. That mission was followed by the Shenzhou 10 manned docking in June 2013. Six months later, China launched its robotic Chang'e 3 lunar lander/rover, and it landed on the moon on Dec. 14.

It wasn't only the Shenzhou and the Chang'e 3 missions that stimulated U.S. interest to China's space program. It was also the marked increase in the number of launches by Chinese Long March rockets. China averaged 4.4 Long March missions annually during 1995-1999, 4.8 in 2000-2004 and eight per year in 2005-2009. The Long March launch rate rose sharply in 2010 to 15 launches, followed by 15 in 2011 and 17 in 2012.

Not only was China accelerating its Long March program, it was launching more diverse and more powerful versions of the rocket. During 2005-2009, Long March models launched included the 2C, 2D, 2F, 3A, 3B, 3C, 4B and 4C — eight different models. Of those, the 3C and 4C models were new.



Source: Marco Cáceres

During 2010-2014, models launched included the eight listed above plus two others — 10 in all. The Long March 3B/E launched was a new model, while one called the Kuaizhou was an entirely new rocket.

Taking notice

The surge in Chinese launches certainly caught the Obama administration's attention and may have been the key incentive for the U.S. government to begin earnestly finding ways to develop a close working relationship with China in space. In January 2014, NASA officials met with representatives from the China National Space Agency and the China Manned Space Agency at a conference in Washington, D.C., sponsored by the U.S. State Department and the International Academy of Astronautics.

Bolden met with his counterpart at the CNSA, Xu Dazhe. Again, he publicly expressed the U.S.'s desire to cooperate with China. "We are looking for ways to find different ways we can be a partner to them," Bolden said.

What is not lost on the Obama administration is that the Chinese have been using their sizable rocket fleet to launch more military satellites. In looking at all the satellites launched by China during the 1995-2004 time frame, only several were dedicated military satellites. This began to change in 2005, and from 2005-2009, China launched 13 military satellites — an average of two to three annually. Those military-related launches — at least from a de facto standpoint — are "acknowledged" by China, in the sense that the government refers to the People's Liberation Army involvement in certain space programs such as the Tiangong 1 mission.

In 2010, China launched seven military satellites. Five were Yaogan Weixing surveillance satellites, the Tianhui-1A was a mapping satellite and the Chinasat 20A was for communications. As the Chinese numbers increased, the number of military satellites launched averaged about six per year during 2010-2013.

Last year, however, the number shot up dramatically to 13 — 10 Yaogan Weixings and three Shijian early-warning satellites. And 12 of the 13 satellites were launched aboard eight rockets during the August-December span. That is an extremely unusual surge of military launch activity for any country, and that activity was certain to spur concern within the Obama administration, particularly the Pentagon, about China's motives.

In November 2014, Bolden visited China and met again with Xu Dazhe. A NASA release issued after the meeting stated that the agency heads had "agreed to strengthen communications and exchanges." The NASA administrator also met with Wang Zhaoyao, director of the China Manned Space Engineering Office. While specifics of the talks have not been made public, Bolden said in interviews to media outlets including Aviation Week and Space News in December 2014 at Kennedy Space Center that it was a "listening opportunity" for him.

A request on collisions

Perhaps the most interesting twist to the

quickly evolving relationship between the U.S. and China on space was the news that broke in December that China had formally requested that the U.S. Air Force Space Command provide space situational awareness reports, or close-approach notifications — also known as "conjunction warnings" — directly to the Chinese military instead of sharing them via the State Department.

The reports China receives include data about possible collisions between orbiting satellites and space debris. The newspaper Defense News quoted Air Force Gen. John Hyten, head of Air Force Space Command, as saying, "It takes a long time to get through that process, sometimes too long. It's a big deal because [the Chinese] asked for that kind of information direct, and I think that's a good thing.... Because that is the kind of international partnership we need to think about."

Hyten's comments implied that the simple act of China reaching out to the U.S. by making the request signaled a desire for a cooperative relationship in exchanging space-related information. That is significant, and may have created a critical opening for establishing a broader space partnership between the two countries.

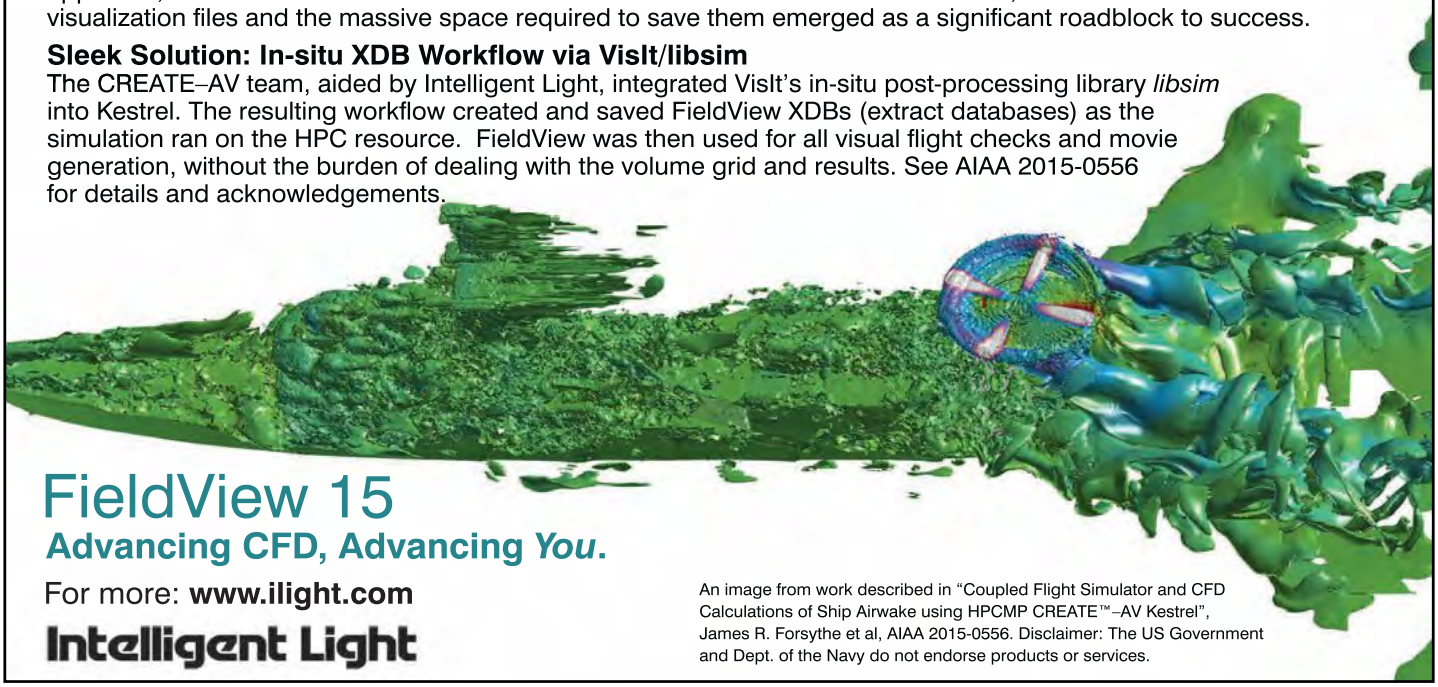
It also might have provided a needed offset to a closer relationship between China and Russia in the realm of space. Consider that during the past year, while NASA has suspended cooperation with the Russian space agency Rosaviakosmos because of Russia's annexation of the Crimea and intervention in eastern Ukraine, the Chinese National Space Agency and Rosaviakosmos have been signing agreements to increase cooperation.

China's growing technical capabilities in space, along with robust launch schedules and an expanding fleet of surveillance satellites, provide enough reason for the U.S. to be wary of the Chinese but also signal an effort to draw closer to them. Particularly when the emerging space partnership between the Chinese and the Russians demonstrates the need.

News From Intelligent Light

Big Data, Big Challenge
The CREATE™–AV team undertook a simulation challenge last year: coupling the CFD solver, HPCMP CREATE–AV Kestrel, to the Navy flight simulator, CASTLE® for a fully coupled rotorcraft simulation in a ship's airwake. The approach, hover and land had a simulation duration of 45 seconds. The time to save, transfer and read these visualization files and the massive space required to save them emerged as a significant roadblock to success.

Sleek Solution: In-situ XDB Workflow via VisIt/libsim
The CREATE–AV team, aided by Intelligent Light, integrated VisIt's in-situ post-processing library *libsim* into Kestrel. The resulting workflow created and saved FieldView XDBs (extract databases) as the simulation ran on the HPC resource. FieldView was then used for all visual flight checks and movie generation, without the burden of dealing with the volume grid and results. See AIAA 2015-0556 for details and acknowledgements.



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An image from work described in "Coupled Flight Simulator and CFD Calculations of Ship Airwake using HPCMP CREATE™–AV Kestrel", James R. Forsythe et al, AIAA 2015-0556. Disclaimer: The US Government and Dept. of the Navy do not endorse products or services.

Taming the unmanned skies

Safety technologies and regulations have lagged far behind the exploding market for small unmanned aircraft. Debra Werner and Philip Butterworth-Hayes explain how that is changing.

Not long after a remote-controlled quadcopter plunked down on the White House grounds on a January night, Europeans had a similar wakeup call when five small unmanned craft mysteriously appeared above Paris landmarks.

These events may go down in history as crucial motivators in the national and international efforts to establish rules and technologies for safe operation of this new class of aircraft. Three weeks after the White House incident, the FAA released its long-awaited draft rules describing how it proposes to regulate nonrecreational flights of unmanned craft weighing less than 55 pounds. Similar regulatory efforts are now underway from Europe to Australia and within the International Civil Aviation Organization. On the technology front, the industry is hard at work on automated tracking and geo-fencing software that could prevent more incidents like those in Washington and Paris.

The stakes are huge for safety advocates and also for makers of aircraft, avionics and software. Whether the planes are called unmanned aircraft systems, drones, or remotely piloted planes, one thing is clear: They are proliferating. The number in operation will top the 1 million mark this year, predicted the U.K. management consultant Deloitte in January. Seven hundred thousand are already in use, according to Deloitte. Over 300,000 units are expected to be sold in 2015 worth between 125 million pounds and 250 million pounds ($192.8 million to $385.6 million).

The proposed rules for safe operation of these planes share specific, common principles: The aircraft must remain within sight of their operators at all times; they must not be flown over populated areas; operators must maintain a separation distance of more than 5 kilometers (3.2 miles) from airports and they must remain 400 or 500 feet in altitude, with different countries specifying slightly different altitudes.

Many countries, same rules

In Europe, the challenge has been to integrate all the different national regulations within a single agreed format, according to Peter Van Blyenburgh, president of UVS International, a Paris-based global association of small unmanned plane operators and manufacturers. In Germany, for example, each of the country's 16 different states has developed its own rules for aircraft with a maximum take-off mass of less than 5 kilograms (11 pounds). "We expect a clear recommendation of how all national rules should be harmonized at a European level to be one of the conclusions of the high-level conference on remotely piloted air-

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DJI

DJI, manufacturer of the Phantom 2 quadcopter that saw one of its models crash on the White House grounds, says it is imposing safeguards on its models so that operators won't be able to fly the aircraft into U.S. no-fly zones.

craft systems taking place in Riga at the start of March," he says. Van Blyenburgh notes that there are now over 1,000 registered operators of small unmanned planes in France alone.

Meanwhile, in Australia, the Civil Aviation Safety Authority has drawn up proposals that would make it easier for operators of remotely piloted air vehicles of 2 kilograms and below to operate their vehicles. No longer would operators be required to have a remote pilot certificate or an operator's certificate. Australia, where there are more than 150 civil registered operators, was one of the first countries to develop regulations, drawing up Civil Aviation Safety Regulation Part 101 in October 2001. The latest proposed amendments to this regulation include the requirement to fly at least 30 meters (98 feet) away from any person not directly involved in the operation of the plane and to not operate the aircraft above 400 feet altitude.

Stray drones

While these new regulations should enable an increase in activity among commercial operators in areas such as crop monitoring, mapping and infrastructure inspection, they will not directly address the issue of non-regulated planes appearing in sensitive areas. According to one European regulator, this is essentially a law enforcement issue that, although based on aviation safety regulations, will need to be addressed by security agencies rather than aviation safety regulators.

In the last few months, a number of agencies have started to look at technical solutions to the problem of planes straying into sensitive areas. In the Netherlands, for example, the Dutch National Aerospace Laboratory and plane manufacturer Aerialtronics have launched the Interceptor project to research the possibility of using "intelligent" small unmanned planes to intercept any unmanned planes that pose a potential hazard to public security. The interceptors would take control of the targets and steer them to the ground.

Van Blyenburgh, the UVS International president, suggested unmanned aircraft adopt another type of technology. "It should be possible to fit commercial remotely piloted aircraft with an electronic identity chip containing its official registration number, which would allow them to be interrogated quite quickly, easily and cheaply by law enforcement personnel and to identify the aircraft, as well as its owner," he says.

Technical solutions

Many experts believe another effective system would be geo-fencing — fitting planes

by Debra Werner and Philip Butterworth-Hayes



No-fly zones: Using data from OpenStreetMap, the open-source mapping firm Mapbox released a map showing where unmanned aerial systems can and cannot fly in the United States. Jurisdictions such as airports, national parks and military bases are off limits, along with the Washington, D.C., region, where Mapbox is based.

with software to automatically prevent them from flying into prohibited areas.

DJI, the Chinese manufacturer of the small quadcopter that crashed close to the White House, announced soon after the incident that it would be issuing a mandatory system software update to disable its camera-equipped drones in Washington's no-fly zone, as well as other no-fly zones. The owners of DJI's craft are responsible for downloading the software update through the Internet, similar to updating an iPhone or printer software.

Even before the White House incident, DJI considered itself an industry leader in geo-fencing. "We are the only company that proactively built a geo-fence [capability] into our systems and made it a requirement for operations," says Michael Perry, spokesman for DJI, based in Shenzhen, China.

DJI issued firmware — also via updates received over the Internet — in April 2014 to keep Phantoms from flying near 750 major airports and other no-fly zones. Since then, the company has been working on a more comprehensive version of Phantom firmware that will prevent operations near 10,000 airports, international borders and other restricted areas, including within 25 kilometers (16 miles) of downtown Washington.

DJI issued that update Jan. 30, but pulled it a week later when company officials discovered a bug. An improved version was issued on March 3. The new firmware warns Phantom operators when their aircraft approach a restricted area. If the operator continues to send the unmanned aircraft toward the no-fly zone, the software gradually limits its altitude, eventually forcing it to either turn back or land.

Instead of preventing unmanned aircraft from operating anywhere in Washington, some industry executives hope to create a more sophisticated system that would establish individual geo-fences for specific unmanned aircraft flights. In this scenario, operators would send four key pieces of information to a digital cloud created by a third party. They would report the type of aircraft, who plans to operate it, where and when. Based on that information, the operator would gain access to an operating area ranging from 1,000 feet on a horizontal plane and 400 feet in altitude to a more limited perimeter due to an approaching storm or a helicopter in the vicinity.

"It's really easy to create a geo-fence," says Chris Anderson, chief executive of 3D Robotics of Berkeley, California, which builds small unmanned aircraft for consumers and businesses. "It's hard to do it well."

It's also hard to find a comprehensive list of no-fly zones, says Justin Miller, vice president for product development at Ares Drones Ltd., a commercial unmanned aircraft developer in State College, Pennsylva-

nia. In the United States, for example, unmanned aircraft are prohibited from flying near airports, national parks, military facilities, power plants, dams and fuel refineries. In addition, the FAA frequently issues Temporary Flight Restrictions. On March 6, for example, the FAA restricted air traffic around Columbia, South Carolina, from 11:15 a.m. to 4:15 p.m. Eastern Standard Time while President Barack Obama was visiting Benedict College.

Airplane pilots who want to know whether their intended flight paths will take them near restricted areas, know how to look up that information online or call the nearest airport. "That is a lot to ask of a hobbyist flying a small unmanned aircraft," Miller says. "We know most people are law-abiding citizens who will follow the law if they know about it. Most don't know what areas are restricted."

Protecting airliners

A common nightmare among regulators is that one day a wayward craft could collide with an airliner or be ingested in one of its engines, causing a crash. One way to reduce the risk could be to give operators easier access to information about restricted areas.

Ares Drones, a startup established in 2014 by three Pennsylvania State University information technology managers, created FlySafe, an Apple app that gives users access to maps showing restricted flight zones of varying sizes around U.S. airports, in addition to information on local weather and wind conditions. "We started with airports," Miller says. "We don't yet have parks or nuclear facilities on our maps because our main concern is with the safety of manned flights."

In the 2012 FAA Modernization and Reform Act, Congress called on the FAA to establish rules that would prevent unmanned aircraft from flying within 5 miles of U.S. airports without providing the airport operator and air traffic control tower with prior notice of planned operations. The FAA's proposed rules for unmanned aircraft that weigh less than 55 pounds, released Feb. 15, would carry those restrictions further by requiring operators to get advance permission from air traffic control before flying their planes in class B, C, D and E airspace. Airspace around airports is designated Class B, C and D, with the Class B designation going to the busiest ones. Class E is a catch-all designation for controlled airspace that does not fit in another category. Class E airspace often is adjacent to another controlled airspace, leaving room for airport approach and departure routes, for example



AeroVironment

The FAA issued type certificates in the restricted category in 2013 to the AeroVironment Puma AE, which permitted operators to use the aircraft for commercial purposes. The International Civil Aviation Organization and member states are drawing up global rules based on the framework of current laws mainly written by participating countries.

If that proposed rule is enacted, unmanned flights would be prevented from flying within 10 miles of some of the busiest U.S. airports or within 30 miles if the aircraft don't carry a Mode C Transponder, which allows air traffic controllers to view the aircraft's altitude on radar screens. The FAA proposes creating a separate subclassification for "micro" aircraft defined as those weighing less than 4.4 pounds. The FAA would let those craft fly over people provided the micro aircraft are made of "materials that break, distort, or yield on impact."

Because it's so difficult to keep track of a complex and changing list of no-fly zones, unmanned aircraft producers are looking for help from companies including SkyWard of Portland, Oregon. SkyWard creates software to help businesses manage unmanned aircraft operations, including steering clear of no-fly zones.

"Ultimately, we hope people will learn the local rules and restrictions before they fly," DJI's Perry says. That was the case for the vast majority of the hobbyists who, in years past, built model airplanes in their backyards and flew them in nearby parks. With the proliferation of increasingly capable unmanned planes, however, unmanned aircraft manufacturers realize geo-fencing is becoming increasingly necessary.

The old aerospace model relied on trained operators. The new unmanned vehicles are so smart and automated, they require little or no training. "We've made them so smart you can do dumb things with them," Anderson says. "Now, we have to make them even smarter so you can't."

25 Years Ago, April 1990



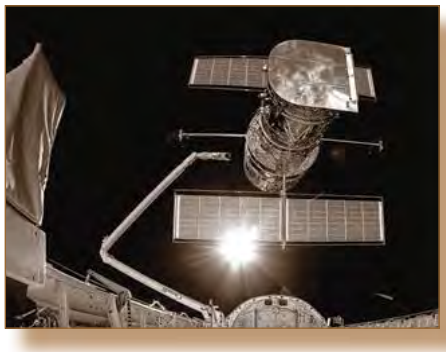
April 5 The world's first air-launched satellite, PegSat, is orbited by Orbital Sciences Corp.'s Pegasus satellite launcher. Pegasus is carried by a NASA B-52 aircraft, then released at 43,000 feet. At a safe distance, the launcher is ignited. The all-solid-fuel, three-stage Pegasus is designed to launch light payloads at far less cost than by the conventional ground-launched means. PegSat is a 422-pound communications satellite. Pegasus subsequently launches more than 70 satellites in about 30 missions up to 2002. NASA, Astronautics and Aeronautics, 1986-90, p. 209.

April 7 China launches AsiaSat 1, a salvaged spacecraft. AsiaSat 1 is the former Westar 6 that was salvaged by Space Shuttle mission 51A in 1985 and restored for use. NASA, Astronautics and Aeronautics, 1986-90, p. 261; Aviation Week, April 16, 1990, pp. 25-26.

April 7 The Energetic Gamma Ray Experiment Telescope (EGRET) is deployed from the Space Shuttle Atlantis, mission STS-37, as part of the 35,000-pound Gamma Ray Observatory to measure gamma rays of most of the celestial sphere. By January 1992, EGRET finds three new gamma ray quasars, 200 gamma ray bursts and the best observation of gamma radiation from the Milky Way, prompting scientists to call it the second of NASA's "Great Observatories." The first is the Hubble Space Telescope. On the same Shuttle flight, launched April 5, the astronauts talk to school children while orbiting the United States. NASA, Astronautics and Aeronautics, 1991-1995, pp. 47, 166-167.

April 8 Astronauts Jerry Ross and Jay Apt make the first unscheduled U.S. repair in space, conducting space walks to fix a stuck satellite antenna while flying the Shuttle Atlantis. NASA, Astronautics and Aeronautics, 1991-1995, p. 47.

April 24 Space Shuttle Discovery is launched and on April 25 deploys the 25,000-pound, $1.5 billion Hubble Space Telescope, which is designed to conduct a variety of astronomical observations toward deep space over 15 years. On June 27, NASA announces a flaw in the mirror but this is later fixed and the Hubble makes astounding astronomical discoveries. NASA, Astronautics and Aeronautics, 1986-90, pp. 263-264, 269, 331.



50 Years Ago, April 1965

April 1 For the first time, the first stage of the Saturn 1B launch vehicle, the S-1B-1, is successfully static-fired in a test at NASA's Marshall Space Flight Center. This stage is powered by eight Rocketdyne H-1 engines, each generating 200,000 pounds of thrust. The test lasts for eight seconds. MSFC Release 65-75.



April 2 Walter Henry Barling Sr., who developed and built the famed Barling triplane bomber in 1923 for Gen. William "Billy" Mitchell, dies at 75. At the time, the Barling bomber is the world's largest aircraft. However, in flight tests it is found to be underpowered and only remains a prototype. New York Times, April 5, 1965, p. 31.

April 3 The Atomic Energy Commission's Snapshot spacecraft, carrying the SNAP-10A nuclear reactor, is successfully launched by an Atlas-Agena from Vandenberg Air Force Base, California. Four hours after ejection into orbit, the satellite's 250-pound nuclear reactor is activated by a radio command from Earth. Later in the mission, it is determined that SNAP-10A successfully generates 620 to 668 watts of electricity for an ion engine that produces a thrust of two-thousands of a pound. This is the first test of a reactor-ion system in orbit, although it is limited to a 90-day test. Washington Post, April 4, 1965; Missiles and Rockets, April 12, 1965, p. 13.



April 6 Early Bird 1, also known as Intelsat 1, the first commercial communications satellite, is successfully launched by a Thrust-Augmented Delta rocket from Cape Kennedy, Florida. Early Bird was developed for the COMSAT Corp. that manages the satellite. Early Bird 1 is the first link in COMSAT Corp.'s planned worldwide satellite communications system for relaying radio, TV, Teletype and telephone messages between the United States and Europe. New York Times, April 7, 1965.

April 16 The Saturn 5's first stage (S-1C) is static-fired for the first time in which the five F-1 engines generate a total of 7.5 million pounds of thrust for 6.5 seconds, at the Marshall Space Flight Center, Alabama. This is the first full cluster test made on the recently completed 400-foot-tall test stand. MSFC Release 65-92.



April 22 The USNS Croatan seagoing launch ship arrives at Valparaiso, Chile, completing its expectation of

Past

An Aerospace Chronology
by **Frank H. Winter**
and **Robert van der Linden**

launching 77 sounding rockets with scientific experiments off the west coast of South America. These rockets included Nike-Cajuns and Nike-Apaches. The expedition is part of the 1964-1965 International Quiet Year of the Sun to study various aspects of solar phenomenon worldwide. NASA Wallops Island, Virginia facility, Release 65-22.



April 23 The Soviet Union's Molniya-1, or Lightning 1, communications satellite is launched and makes two orbits daily, one over the USSR and the other over North America. Molniya is powered by solar cells that are mounted on each of its six outstretched panels that radiate from its cylindrical base. Molniya is strictly experimental but also succeeds in the USSR's experimental TV broadcast from Vladivostok to Moscow. Flight International, July 8, 1965, p. 69; Aviation Week, May 3, 1965, p. 21.

April 29 The Mariner 4 Mars probe establishes a new space communications distance record of 66 million miles, exceeding the previous record of 65 million miles set by the Soviet Union's Mars 1 probe when contact with it was lost on March 21, 1963. NASA Release 65-24; Aviation Week, May 10, 1965, p. 39.

April 29 The Explorer 27 (BE-C) satellite is launched into orbit at NASA's Wallops Island facility by a four-stage solid-propellant Scout vehicle. The primary mission for the windmill-shaped satellite is geodetic measurements, including irregularities in the Earth's gravitational field, as well as ionospheric studies. NASA Wallops Island facility, Release 65-24.

75 Years Ago, April 1940



April 1 The new twin-engined Grumman F5F-1 Skyrocket starts flying trials for the U.S. Navy. The plane is powered by two 1,200-horsepower Wright Cyclones, and has a maximum speed of 383 mph. The Skyrocket is 28.5 feet long with a 42-foot span. Interavia, April 23, 1940, p. 5.

April 5 The USSR's MiG-1 prototype aircraft, designed by Artyom Mikoyan and Mikhail Gurevich, flies for the first time. By August, it will pass its state acceptance tests and become the first of the famous MiG fighters. William Green, Warplanes of the Second World War, Volume 3, pp. 140-141.



April 5 A new movie featuring the German air force, "Die Feuertaufe" ("Baptism by Fire"), premieres in Berlin, depicting Luftwaffe operations in Poland and including a warning against Britain. Field-Marshal Hermann Goering makes a brief appearance and says: "What the German Air Force promised in Poland, it will fulfill against Great Britain and France." Interavia, April 9, 1940, p. 16.

April 9 Germany invades Norway, with parachutist assaults on Oslo and Stavanger and landings on the coast. B.H. Liddell Hart, History of the Second World War, pp. 51-63.

April 20 The USS Curtiss, the first seaplane tender built for the Navy, is launched at the New York Shipbuilding Corp's yard. Interavia, May 16, 1940, p. 13.



April 25 The USS Wasp is commissioned. Built in Quincy, Massachusetts, by Bethlehem Shipbuilding, the 741-foot-long Wasp will play a key role during the Axis bombing of Malta in April 1942. President Roosevelt will loan the Wasp to Britain, which will order the ship to convey about 50 of the desperately needed fighters from Scotland to Malta. The aircraft will be launched from Wasp's deck from the south of Sardinia to Maltese airstrips, the first and only time in the war that air force aircraft of one ally are launched from an aircraft carrier of another. "USS Wasp" file, National Air and Space Museum.

100 Years Ago, April 1915



April 1 French pilot Lt. Roland Garros shoots down a German Aviatik near Ostend with an improved forward-mounted gun made in 1914 by the engineer Raymond Saulnier. Working with Saulnier and a mechanic, Garros added deflector plates on the propellers' blades in the event the bullets strike them. With the new system, he shoots down other planes but on April 18 his plane is struck by enemy fire and captured. The Germans learn of the system and request Dutch engineer Anthony Fokker to duplicate it. While Fokker had earlier patented a synchronizer device, his engineers greatly improve it and produce the first successful synchronized in-line aircraft gun that revolutionizes aerial combat. It is also during this period that Garros' five aerial victories make him the first "ace" of the war. Charles Christienne and Pierre Lissarague, A History of French Military Aviation, p. 92.

Florida State University
Strategic Faculty Recruitment

Florida State University seeks to strengthen the research programs among the centers located in Southwest Campus by recruiting six to eight creative, highly qualified faculty who have a proven record of interdisciplinary research across engineering and science disciplines. These positions are an integral part of the FSU's efforts to enhance research and education in the STEM disciplines. These new faculty members will be part of the College of Engineering or the College of Arts and Sciences, but will leverage the existing programs and facilities to substantially strengthen interdisciplinary and synergistic research across the centers. These centers include the Aeropropulsion, Mechatronics and Energy (AME) Center, the Applied Superconductivity Center (ASC), the Center for Advanced Power Systems (CAPS), The Florida Center for Advanced Aero-Propulsion (FCAAP), and the High-Performance Materials Institute (HPMI). Each center is equipped with state-of-the art research facilities and infrastructure which enables them to conduct highly interdisciplinary research and provide education and training across traditional discipline boundaries. This search is part of the university's focus on enhancing interdisciplinary research through these centers and a follow-up to the recent successful strategic hiring of 11 outstanding faculty in the Energy & Materials Initiative.

We seek applicants at mid-career or senior level who have an established *record of innovation, sustained externally funded research, a high research profile* and *excellence in teaching.* Evidence of interdisciplinary research is critical. Though the search is open to highly qualified applicants in a broad range of disciplines, some areas that may offer the best opportunity for *interdisciplinary research* between two or more centers include:

- *Advanced diagnostics* and with emphasis on *flows* with applications.
- *Computational Sciences* with emphasis in *fluid dynamics*, especially at high Reynolds number, and/or fluid-structure interactions at macro through nano-scales.
- *Dynamics and Controls* with applications in *flight mechanics* and/or control of complex systems such as *smart grid infrastructure* and *advanced manufacturing*
- *Systems integration of Smart Grid infrastructure*, including controls and disturbance propagation; economic analysis related to diverse sources of energy for smart grid implementation.
- *Advanced materials fabrication and characterization; especially superconductors* for applications such as *high field, high power* and *high energy systems* and *high sensitivity detectors*
- *Systems optimization, engineering economics and human factors/ergonomics* in emerging areas, such as advanced manufacturing, nano-manufacturing and renewable energy.
- *Advanced modeling, structure design and multi-scale manufacturing* of composites/nano-composites and smart materials/structures. Applications include *sensors, actuators, energy devices, electronics* in *aerospace, energy* and *structural health monitoring.*

Successful candidates are expected to make significant contributions to scientific leadership in their areas and participate in teaching and mentoring at the undergraduate and graduate levels. A highly competitive salary and start-up package, high quality research space and access to state-of-the-art instrumentation, computing and research facilities in academic and interdisciplinary units will be offered. The home department and research center will be determined by the candidate's field of expertise but the focus will center on departments primarily within the College of Engineering as well as in the College of Arts and Sciences.

Complementing the above collaborative centers is the National High Magnetic Field Laboratory (NHMFL), of which the Applied Superconductivity Center is a division. Applicants are asked to provide *a single document* in PDF format containing a letter of application, a curriculum vitae, a two page narrative describing their research interests and plans, and a brief teaching statement. Applications must be sent electronically to **ame-centersearch-2015@fsu.edu**. Highly ranked applicants will be contacted at a later date for the purpose of requesting letters of recommendation. Review of applications is expected to begin in Spring 2015 and will continue until the positions are filled. Please visit the following site for more information:
http://research.fsu.edu/ads/strategic-faculty-recruitment/

Florida State University is committed to the diversity of its faculty, staff, and students, and to sustaining a work and learning environment that is inclusive. Women, minorities, and people with disabilities are encouraged to apply. FSU is an Equal Opportunity/Access/Affirmative Action/Pro Disabled & Veteran Employer.



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AIAA Bulletin



On 4 March, AIAA members went to Capitol Hill for Congressional Visits Day to meet with members of Congress and raise awareness of the long-term value that science, engineering, and technology bring to the United States. Rep. John Culberson (R-Texas) took time to meet with several AIAA representatives. From left to right: Steve Sidorek, AIAA; Rep. John Culberson; Mark Bowman, AIAA; Greg Johnson, AIAA; Hannah Thoreson, AIAA. (See full story on page **B7**)

APRIL 2015

AIAA Meeting Schedule	B2
AIAA News	B5
AIAA Propulsion and Energy 2015 Event Preview	B12
AIAA Courses and Training Program	B15

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† U.S. only. International callers should use 703/264-7500.

All AIAA staff can be reached by email. Use the formula first name last initial@aiaa.org. Example: megans@aiaa.org.

Addresses for Technical Committees and Section Chairs can be found on the AIAA Web site at **http://www.aiaa.org**.

We are frequently asked how to submit articles about section events, member awards, and other special interest items in the *AIAA Bulletin*. Please contact the staff liaison listed above with Section, Committee, Honors and Awards, Event, or Education information. They will review and forward the information to the *AIAA Bulletin* Editor.

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2015			
13–15 Apr†	**EuroGNC 2015, 3rd CEAS Specialist Conference on Guidance, Navigation and Control**	Toulouse, France (Contact: Daniel Alazard, +33 (0)5 61 33 80 94, alazard@isae.fr, w3.onera.fr/eurognc2015)	
13–17 Apr†	**2015 IAA Planetary Defense Conference**	Frascati, Italy (Contact: William Ailor, 310.336.1135, william.h.ailor@aero.org, www.pdc2015.org)	
5 May	**AIAA Fellows Dinner**	Crystal City, VA (https://www.aiaa.org/FellowsDinner2015)	
6 May	**Aerospace Spotlight Awards Gala**	Washington, DC	
25–27 May†	**22nd St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia, (Contact: Prof. V. G. Peshekhonov, 7 812 238 8210, icins@eprib.ru, www. Elektropribor.spb.ru)	
4 Jun	**Aerospace Today ... and Tomorrow—An Executive Symposium**	Williamsburg, VA	
16–19 Jun†	**7th International Conference on Recent Advances in Space Technologies – RAST 2015**	Istanbul, Turkey (Contact: Capt. M. Serhan Yildiz, +90 212 6632490/4365, syildiz@hho.edu.tr or rast2015@rast.org.tr)	
20–21 Jun	**Optimal Design in Multidisciplinary Systems**	Dallas, TX	
20–21 Jun	**FUN3D Training Workshop**	Dallas, TX	
22–26 Jun	**AIAA AVIATION 2015 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **21st AIAA/CEAS Aeroacoustics Conference** **31st AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **33rd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **7th AIAA Atmospheric and Space Environments Conference** **15th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Complex Aerospace Systems Exchange** **22nd AIAA Computational Fluid Dynamics Conference** **AIAA Flight Testing Conference** **45th AIAA Fluid Dynamics Conference** **22nd AIAA Lighter-Than-Air Systems Technology Conference** **16th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **46th AIAA Plasmadynamics and Lasers Conference** **45th AIAA Thermophysics Conference**	Dallas, TX	**13 Nov 14**
28 Jun–2 Jul†	**International Forum on Aeroelasticity and Structural Dynamics (IFASD)**	Saint Petersburg, Russia (Contact: Dr. Svetlana Kuzmina, +7 495 556-4072, kuzmina@tsagi.ru, www.ifasd2015.com)	
6–9 Jul	**20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference**	Glasgow, Scotland	**8 Dec14**
12–16 Jul†	**International Conference on Environmental Systems**	Bellevue, WA (Contact: Andrew Jackson, 806.834.6575, Andrew.jackson@ttu.edu, www.depts.ttu.edu/ceweb/ices)	
25–26 Jul	**The Application of Green Propulsion for Future Space**	Orlando, FL	
25–26 Jul	**Advanced High Speed Air Breathing Propulsion**	Orlando, FL	
27–29 Jul	**AIAA Propulsion and Energy 2015 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **51st AIAA/SAE/ASEE Joint Propulsion Conference** **13th International Energy Conversion Engineering Conference**	Orlando, FL	**7 Jan 15**
30–31 Jul	**Business Management for Engineers**	Orlando, FL	
30–31 Jul	**Hybrid Rocket Propulsion**	Orlando, FL	
9–13 Aug†	**2015 AAS/AIAA Astrodynamics Specialist Conference**	Vail, CO (Contact: Dr. W. Todd Cerven, william.t.cerven@aero.org, www.space-flight.org/docs/2015_astro/2015_astro.html)	
29–30 Aug	**Introduction to Space Systems**	Pasadena, CA	
31 Aug–2 Sep	**AIAA SPACE 2015 (AIAA Space and Astronautics Forum and Exposition)**	Pasadena, CA	**10 Feb 15**

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
7–10 Sep†	**33rd AIAA International Communications Satellite Systems Conference and Exhibition (ICSSC-2015)**	Gold Coast, Australia (Contact: Geri Geschke, +61 7 3414 0700, Geri.geschke@emsolutions.com.au, www.satcomspace.org)	**1 Apr 15**
13–17 Sep†	**34th Digital Avionics Systems Conference**	Prague, Czech Republic (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)	
22–25 Sep†	**3AF/AIAA Aircraft Noise and Emissions Reduction Symposium**	La Rochelle, France (www.aners2015.com)	**30 Apr 15**
23–24 Sep†	**19th Workshop of the Aeroacoustics Specialists' Committee of CEAS and 5th Scientific Workshop of the European X-Noise EV Network**	La Rochelle, France (www.aners2015.com)	
12–16 Oct†	**66th International Astronautical Congress**	Jerusalem, Israel (Contact: www.iac2015.org)	
2016			
4–8 Jan	**AIAA SciTech 2016** **(AIAA Science and Technology Forum and Exposition)** **Featuring:** **24th AIAA/AHS Adaptive Structures Conference** **54th AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **15th Dynamics Specialists Conference** **AIAA Guidance, Navigation, and Control Conference** **AIAA Information Systems—Infotech@Aerospace Conference** **AIAA Modeling and Simulation Technologies Conference** **18th AIAA Non-Deterministic Approaches Conference** **57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **9th Symposium on Space Resource Utilization** **3rd AIAA Spacecraft Structures Conference** **34th Wind Energy Symposium**	San Diego, CA	**2 Jun 15**

Call for Nominations

AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award

Nominations are currently being accepted for the 2016 AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award. The recipient will receive a certificate and a $7,500 honorarium.

This award is jointly sponsored by the American Institute of Aeronautics and Astronautics (AIAA),the American Association of Airport Executives (AAAE) and the Airport Consultants Council (ACC).

It honors the nominee(s) judged to have contributed most significantly in recent years to the enhancement of relationships between airports and/or heliports and their surrounding environments via exemplary innovation that might be replicated elsewhere. Such enhancements might be in airport land use, airport noise reduction, protection of environmental critical resources, architecture, landscaping or other design considerations to improve the compatibility of airports with their communities, etc.

Please go to www.aiaa.org/speasaward for further information or to download the nomination form. Presentation of the award will be made at the AAAE/ACC Planning, Design, and Construction Symposium, scheduled for February 2016. The recipient will be asked to make a brief presentation describing their accomplishment/ contribution and how it could be replicated elsewhere by other airports.

DEADLINE for submission of nominations is November 1, 2015.
CONTACT: AIAA Honors and Awards Program • 703/264-7623 • carols@aiaa.org

www.aiaa.org/speasaward

15-600

AIAA AAAE ACC AIRPORT CONSULTANTS COUNCIL

Meeting Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
25-28 Jan†	**Annual Reliability and Maintainability Symposium (RAMS)**	Tucson, AZ (Contact: Sean Carter, seancarter67@gmail.com, www.rams.org)	
5–12 Mar†	**2016 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, Erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
13–17 Jun	**AIAA AVIATION 2016** **(AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **34th AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **8th AIAA Atmospheric and Space Environments Conference** **16th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference** **46th AIAA Fluid Dynamics Conference** **17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **47th AIAA Plasmadynamics and Lasers Conference** **46th AIAA Thermophysics Conference**	Washington, DC	
25–27 Jul	**AIAA Propulsion and Energy 2016** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **52nd AIAA/SAE/ASEE Joint Propulsion Conference** **14th International Energy Conversion Engineering Conference**	Salt Lake City, UT	
13–15 Sep	**AIAA SPACE 2016** **(AIAA Space and Astronautics Forum and Exposition)**	Long Beach, CA	

For more information on meetings listed above, visit our website at www.aiaa.org/calendar or call 800.639.AIAA or 703.264.7500 (outside U.S.).
†Meetings cosponsored by AIAA. Cosponsorship forms can be found at https://www.aiaa.org/Co-SponsorshipOpportunities/.
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From the Corner Office



ADVOCATING FOR AEROSPACE EVERY DAY

Jim Albaugh, AIAA President

On 4 March 2015, AIAA members representing 18 states traveled to Washington, DC, to take part in the Institute's 18th annual Congressional Visits Day (CVD). Throughout the day, our members engaged congressional decision makers in conversations about some of the most pressing issues facing aerospace today: Aerospace and Defense (A&D) Budget Funding and Procurement; A&D Competitiveness; Aerospace Cybersecurity and Safety; and A&D Workforce Enhancement. Above all, our members made sure that Congress heard our voices, realized our concerns, and understood our commitment to ensuring a strong and stable aerospace industry for years to come.

I would like to think that CVD in itself is all that is necessary to ensure that aerospace stays on lawmakers' minds throughout the year, but I am not that naïve. As a community, we must remember that every single day is CVD and that we are all advocates for the aerospace profession – each of us must make sure that we do as much as possible to keep aerospace a priority of our elected officials. Our endorsement will call attention to the legislation needed, and the support required, to keep U.S. aerospace poised as the strong pillar of our economic prosperity and national security that it already is. Let's remember, the U.S. aerospace industry generates some $1.5 trillion dollars in annual economic activity for our nation and creates more than 11 million jobs, making it worthy of our stalwart advocacy.

Nevertheless, we must not confine our efforts solely to the halls of Congress. We must make sure that we are advocates and champions for aerospace with the administration and its relevant departments and agencies. Although it's not as easy to contact the FAA, NASA, or the White House, for example, advancing our policy and legislative priorities requires us all to be active promoters at every level of government, not just participants in CVD.

The paramount issue we must tackle is the ongoing battle to achieve budget stability and predictability. Sequestration still looms large on the horizon, with its mandated across-the-board funding cuts triggered if the Bipartisan Budget Act expires at the end of the fiscal year. Consequently, there would be diminished hope for a stable and predictable budget that our sector can rely upon for ongoing missions, contracts, and research and development (R&D) programs. In effect, sequestration would scuttle our community's present and future, and hamper our ability to respond to changing global technology and security threats, in one stroke. I have written on this issue before, and it is simply too large and too critical to ignore. Many of our allies—and our adversaries—do not face these constraints. The United States' global competitors make A&D a national priority as they attempt to match, surpass, or even harm us. We cannot afford to rest on our past accomplishments and simply say "remember when" aerospace R&D was a national priority? We must ensure that our elected officials understand the importance of a predictable and stable budget for aerospace, and that means that we must become "everyday" advocates, not just "once a year" advocates.

The budget aside, there are several other important issues that Congress and the administration grapple with, issues that compel us to keep the advocacy for aerospace going beyond our yearly visits. From a procurement system desperately in need of acquisition reform, to reauthorization of the Export-Import Bank, to the reauthorization of the FAA and NASA – one thing is certain: without clear and coherent leadership, aerospace is at risk. Our industry generated $220 billion in total sales in 2013, the last year for which figures are available. The aerospace industry also contributed $110.8 billion to U.S. exports and helped generate a $72 billion foreign trade surplus, helping drive our nation's economy. That level of economic output demands Congress do what is necessary to streamline our community's ability to procure the goods and services it needs.

The importance of aerospace to our nation, and the constant threats the industry faces, are too great to limit to one day of advocacy each year. The continued promotion of research and development and the establishment of industry-friendly regulations are too critical for AIAA members to sit on the sidelines, hoping that our elected officials will get it right. I am challenging each of you to become an "every day" champion for aerospace. Call or write your member of Congress. Attend one of their events in your district. Or, the next time you are in DC, stop by their office for a visit. Explain to them how this instability and these other pressing needs are directly impacting your industry. No matter what, just make sure Washington hears your voice early and often.

ORANGE COUNTY SECTION'S PREMIER EVENT TO BE HELD IN MAY

The **12th Annual AIAA Southern California Aerospace Systems and Technology (ASAT) Conference and Banquet** is the premier event of the AIAA Orange County Section and will be held on 2 May 2015. This conference brings together Southern California engineers, researchers, educators, students, leaders, and enthusiasts for a program consisting of a number of parallel tracks in both the morning and afternoon sessions. A highly regarded keynote speaker kicks off each session.

ASAT 2015 accepts unclassified presentations on all aspects of aerospace systems, technology, vehicle design, program management, policy, economics and education and will be structured in three major categories:

- Aircraft Systems and Technology
- Space Systems and Technology
- Aerospace Public Policy and Education

The ASAT conferences are carefully planned to provide a forum to exchange new ideas, review achievements, and enable networking opportunities for future aerospace endeavors. They bring together the aerospace sector of Southern California with the hopes of revitalizing the rich history of leadership and innovation in the area. This year, John Rose is the ASAT 2015 Conference Chair

This year's ASAT keynote speakers are: Tom Croslin, Vice President, Boeing Commercial Airplanes SoCal Design Center Engineering, and Elizabeth "Liz" Kaszynski, Videographer and Aerial Photographer at Lockheed Martin. The 2015 banquet immediately following the conference will include an overview of Section activities for the year and presentation of awards for Student of the Year, Young Professional of the Year, Engineer of the Year, and Aerospace Leadership.

The registration deadline is **24 April 2015**. For additional information see the conference website at: http://events.r20.constantcontact.com/register/event?oeidk=a07ea0dfsuy47d3a5c6&llr=vitem6fab&showPage=true.

Aircraft Noise and Emissions Reduction Symposium

La Rochelle, France
22–25 September 2015

The Association Aéronautique et Astronautique de France (3AF) and AIAA are pleased to announce that the 3AF/AIAA Aircraft Noise and Emissions Reduction Symposium (ANERS) will take place in La Rochelle, France, from 22–25 September 2015. This high-level, multidisciplinary technical symposium will bring together leading engineers, scientists, researchers, government and civil aviation officials, industry, and policymakers from Europe and the United States, as well as other regions of the world, to discuss the topics and issues of aircraft emissions and noise reduction. The symposium is being organized by 3AF and AIAA.

The objective of the symposium is to review challenges and opportunities faced by manufacturers, local communities, air carriers, airports, governmental institutions, and nongovernmental organizations to address noise and emission abatement and to develop holistic solutions that will alleviate the pressure associated with air traffic growth.

The format of the ANERS 2015 will be comprised of a series of invited talks in a single-session, panel format and feature leading experts in the field. The program will feature balanced representation from Europe, the United States, and other regions of the world.

Building on the foundations established by the previous events, ANERS 2015 will pursue its comprehensive approach, examining issues from a global perspective, reviewing solutions and assessing their effectiveness to address overarching needs and challenges faced by the aviation community. Current and future solutions to reduce or limit noise and emissions combine the implementation of technologies in engine and aircraft design and manufacturing to control noise/emissions generation/propagation—technologies underpinned by research programs that need to be thoroughly understood—with operational procedures, land-use practices, and market-based options. This review will be achieved through a number of technical sessions dedicated to Local and Global Emissions, Noise and Environmental Interdependencies, and also focusing on recent advances in Mitigation Measures.

In order to emphasize the key role of research and assert the dedication of the symposium to promote this essential part of the solution, the event will associate high-level keynote and invited speeches dealing with recent major initiatives together with selected contributions from research teams all over the world.

As of this year, ANERS will be open to contributed papers on an even proportion with invited speakers. Such contributions will be sought addressing in particular the following topics:

- Achieving a balance with existing and proposed technologies, alternative fuels, tools, procedures and policies
- Achieving a balance amongst noise, local air quality and global emissions
- Achieving carbon neutral growth with global environmental impact reduction, including the reduction of non-CO2 effects
- New insights into the health risks associated with particulate matter, and the way toward PM certification of aircraft engines
- Aircraft noise and its impacts, including social aspects, influence of non-acoustic factors and land-use planning issues
- The aviation infrastructure required for advanced low noise and emissions concepts

Receipt of Extended Abstract: 30 April 2015; Acceptance Notification: May 2015

For more information on the call for papers or the symposium, please visit: **http://www.aners2015.com/?p=92**.

GREATER HUNTSVILLE CELEBRATES AIAA'S 52ND BIRTHDAY

Ken Philippart

The AIAA Greater Huntsville Section commemorated the 52nd anniversary of the founding of AIAA over the last week in January. AIAA was formed on 31 January 1963 from the merger of two predecessor organizations, the American Rocket Society and the Institute of Aerospace Sciences. The Greater Huntsville Section was formed as the Alabama Section of the American Rocket Society in 1952 and was incorporated into AIAA following the merger.

As part of the section's reception honoring its newest class of AIAA Associate Fellows on 23 January 2015, members and guests kicked off the celebration with a traditional birthday cake. Borrowing a tradition from the military services, the longest serving and most junior members in attendance were invited to cut the cake. Dr. Arloe Mayne, with over 50 years of service, joined Young Professional Michael Dunning to do the honors. The two jointly carved the cake, symbolizing the enduring legacy of AIAA and the passing of knowledge from our most experienced members to our up-and-coming leaders.

On 31 January, the section held a celebration at the Huntsville Havoc hockey game. Members and guests attended the game to honor AIAA on 52 years to the day that AIAA was founded.



Image courtesy of Lisa Philippart.

AIAA MEMBERS CAPITOL-IZE ON AIAA CONGRESSIONAL VISITS DAY

On 4 March, AIAA held its 18th annual Congressional Visits Day (CVD) on Capitol Hill. At a breakfast gathering AIAA Executive Director Sandy Magnus welcomed this year's participants and introduced freshman Congressman Steve Knight (R-Calif.), who has been a strong advocate for aerospace over the years and a AIAA longtime supporter.

AIAA members from across the country visited representatives from their state's congressional delegation to raise awareness of the long-term value that science, engineering, and technology bring to the United States. Also in attendance were dozens of student members representing Georgia Institute of Technology, Iowa State University, Louisiana State University, Ohio State University, Pennsylvania State University, Stanford University, and the University of Florida.

While the structure of the event was similar to past years, we narrowed our focus and amplified our message, going to Congress with clear recommendations supporting our key issue areas (see the "From the Corner Office" article on page **B5** for details). Participants had positive discussions about maintaining a vibrant workforce, promoting STEM education, and achieving budget stability.

A few of the day's highlights included a meeting between AIAA Public Policy Committee member John Rose and Rep. Knight. Another group of AIAA members met with Rep. John Culberson (R-Texas), the chairman of the House Appropriations Subcommittee on Commerce, Justice, and Science. Culberson, a supporter of the space program, candidly expressed his views about deep-space exploration and the process that NASA uses to budget its missions.



John Kucharski and John Rose represented AIAA in a meeting with Rep. Steve Knight, (R-Calif.).

AIAA members also met with four U.S. senators: Sen. Cory Booker (D-N.J.), Sen. Ted Cruz (R-Texas), Sen. Cory Gardner (R-Colo.), and Sen. Rob Portman (R-Ohio). In addition to Knight and Culberson, members met with other representatives, including Rep. Judy Chu (D-Calif.), Rep. Chris Van Hollen (D-Md.), Rep. Brian Babin (R-Texas), Rep. Mo Brooks (R- Ala.), Rep. Rob Wittman (R-Va.), Rep. Frank LoBiondo (R-N.J.), Rep. Gerry Connolly (D-Va.), Rep. Bobby Scott (D-Va.), and Rep. Bill Johnson (R-Ohio). Several other participants conversed with senior staffers supporting members of Congress who serve on committees with jurisdiction over aerospace issues.

The day ended with a reception where CVD participants shared their stories and discussed ways to make next year's event even better. CVD 2015 was heralded as a success with AIAA's public policy objectives well received by those in Congress.

Earn the Respect of your Peers and Colleagues

Advance Your Membership



For more information and requirements, please visit **http://www.aiaa.org/Honors** or contact **Patricia A. Carr,** Program Manager, Membership Advancement Program, at **triciac@aiaa.org** or **703.264.7523**

The distinction you gain with each membership advancement earns the respect of your peers and employer – and bolsters your reputation throughout the industry.

AIAA Members who have accomplished or been in charge of important engineering or scientific work and who have made notable valuable contributions to the arts, sciences, or technology of aeronautics or astronautics are encouraged to apply.

ASSOCIATE FELLOW
Accepting Nomination Packages:
15 December 2014 – 15 April 2015

FELLOW
Accepting Nomination Packages:
1 January 2015 – 15 June 2015

HONORARY FELLOW
Accepting Nominations Packages:
1 January 2015 – 15 June 2015

SENIOR MEMBER
Accepting Online Nominations monthly

AIAA
Shaping the Future of Aerospace

CELEBRATING THE LEGACY OF THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Duane Hyland

On the evening of 3 March, nearly 400 members of the aerospace community—representing government, industry, and academia—came together at the National Air and Space Museum in Washington, DC, to celebrate the 100th anniversary of the founding of the National Advisory Committee for Aeronautics (NACA), the predecessor to the National Aeronautics and Space Administration.

Speakers for the evening were Gen. John "Jack" Dailey, USMC (Ret.), the director of the museum; John Holdren, director of the White House Office of Science and Technology Policy; Mike Griffin, AIAA Immediate Past President and former NASA administrator; Robie Samanta-Roy, vice president, Technology and Innovation, Lockheed Martin; and Maj. Gen. Charles Bolden Jr., USMC (Ret.), the current NASA administrator. While each of the speakers had different perspectives, one theme flowed throughout all the remarks—without NACA, its staff, and the research performed by the organization, modern aviation would not be as we know it. Bolden noted that because of NACA's work, aviation has become an economic powerhouse —"generating $1.5 trillion dollars in revenue and sustaining 11 million jobs."



The official presentation by NASA Adminitrator Charles Bolden (left) of the "NACA Wings" sign to the National Air and Space Museum and General J.R. "Jack" Dailey. The NACA sign is seen in the background. Photo Credit: (NASA/Joel Kowsky)

Holdren pointed out that NACA and its innovations in engine cowlings, air foils, blunt body styles for spacecraft and work on supersonic flight sped "the development of flight, from the Wright Brothers to Apollo 11 in less a century." He told attendees that "NACA was one of the first examples of how public and private partnerships ... worked—with NACA working alongside early aircraft manufacturers" to solve pressing problems of flight performance, and create many of the flight components and systems that advanced aviation safety and performance.

Lockheed Martin's Samanta-Roy noted that "aeronautics is the key to America's success," stressing that the work that NACA did on advancing aeronautics, "at a time when aerospace was considered a passing fad," was key to that success.

Griffin discussed the strong links between AIAA's predecessor organization the Institute of Aeronautical Science (IAS) and NACA, including one IAS president, James "Jimmy" Doolittle who also served as director of NACA, and the three AIAA Honorary Fellows who also served as directors of NACA: William Durand, Joseph Ames, and Jerome Hunsaker. Additionally, Griffin pointed out that no less than six AIAA Honorary Fellows served on NACA's Special Committee on Space Technology: H. Julian Allen, Robert Gilruth, H. Gyford Stever, Hugh Dryden, Abe Silversteen, and Wernher von Braun..

Bolden told the audience that NASA "truly stands on the shoulders of giants," praising the men and women of NACA for all the work they did in advancing flight. He concluded by reminding the audience that NASA still performs groundbreaking work in aeronautics and that he was "confident that 100 years from now, his successor would stand in this very spot to extoll all of the technological advances made from now until then," largely due to the pursuit of "innovation" started by NACA and continued by NASA.

A new film, "The NACA at 100: Advancing the Science of Flight," was shown to the attendees, and pointed out that "every single American aircraft that saw service in World War II was wind tunnel tested in NACA facilities," one of the first examples of a public-private partnership. It was also noted that NACA was on the forefront of workforce diversity, such as during World War II when "African American women [were hired] as 'computers,'" or mathematicians involved in analyzing test data. The video drove home the point that "while NASA was created in 1958, it was born in 1915."

The ceremony ended with the official presentation to the National Air and Space Museum of the "NACA Wings" sign, taken from a NACA wind tunnel installation. While the sign has been on loan to the museum for some time, the official transfer now makes the museum the sign's permanent home, preserving its, and NACA's, legacy forever.

AIAA proudly served as the event's organizer. Industry sponsors for the evening were: *Platinum*: Lockheed Martin Corporation. *Gold*: Aerojet Rocketdyne, The Boeing Company, Jacobs, Northrop Grumman, Orbital ATK, SGT, and United Technologies Corporation. *Silver*: Exelis and GE Aviation. *Bronze*: The Aerospace Corporation, Aerospace Industries Association, Booz Allen Hamilton, Performance Associates, SAIC. *Patron*: ARES Corporation, Aurora Flight Sciences, CACI International, Gulfstream Aerospace Corporation, Paragon Space Development Corporation, Purdue University, Schafer Corporation, Sierra Lobo, SpaceX, and the University of Colorado, Boulder.

ANNUAL BUSINESS MEETING NOTICE

Notice is hereby given that the Annual Business Meeting of the American Institute of Aeronautics and Astronautics will be held at Hilton Crystal City, Arlington, VA, on Thursday, 7 May 2015, at 12:00 PM.

William Seymore, AIAA Corporate Secretary/Treasurer

OBITUARIES

AIAA Fellow Brown Died in January

Robert Benton Brown II died 14 January 2015. From an early age, Mr. Brown was fascinated by flight, participating in the Free Flight Model Airplane Contest as a teenager—his first project in a lifetime of design.

Mr. Brown was inspired by his professors at the University of Washington (UW) where his favorite class was three-dimensional geometry. Ties were close between the UW aeronautical engineering department and Boeing, and he worked college summers as a mechanic at the Renton plant. His studies were interupted during World War II, when he served as an Army Air Force lieutenant in India, overseeing maintenance for a 100-plane fleet. He returned to Boeing and the UW after the war, graduating with a B.S. in Aeronautical Engineering in 1947 and an M.S. in 1950.

Boeing CEO T.A. Wilson frequently relied on Mr. Brown's inventiveness, as he did for the B-47's unstable pitch-up—solved by vortex generators still used on aircraft today. Brown and his teams also made significant contributions to other foundational designs including the 747 and 767 landing gears, one-piece rotating fuselage construction, and the low-tail F-22 configuration. During his career at Boeing, he was awarded 10 patents.

In the seven years before his retirement in 1990, Mr. Brown served as Boeing's VP for Product Evaluation. He remained active in aeronautical engineering consulting for companies worldwide, collaborating closely with his lifelong associate, John Swihart.

Mr. Brown was honored with the 1979 AIAA National Award for Design Excellence and the 1999 Aviation Week Laureate Award. In 2007, the UW Aeronautical Engineering Department honored him as Distinguished Alumnus and as one of the Diamond Award winners, for "lifetime contributions to passenger jet development."

AIAA Fellow Heppe Died in January

R. Richard Heppe, president of Lockheed Corporation (1984–1987), died 18 January 2015. He was 91 years old.

Mr. Heppe was educated at Stanford University, receiving a B.S. degree in mechanical engineering in 1944 and an M.S. in aeronautical engineering in 1945. He was a graduate student at California Institute of Technology from 1945 to 1947 and received a Professional Engineer's degree.

Widely recognized nationally as one of the preeminent engineers of his generation, he was a master of advanced design and competitive proposals. In 1947, Mr. Heppe joined Lockheed as an aerodynamics engineer. With special knowledge of supersonic aerodynamics he advanced to department manager, and was involved in advanced designs, including the F-104 fighter aircraft. Later he was chief engineer on the Lockheed Model L-2000 supersonic transport.

In 1967, Heppe was assigned to manage the preliminary design and proposal for a new Navy carrier based antisubmarine warfare (ASW) aircraft. In 1969, when Lockheed won the S-3A Navy competition, Heppe became director of the newly formed Antisubmarine Warfare (ASW) Engineering Branch. In 1974, he became vice president–Navy programs, and later advanced to vice president and general manager, Government Programs, which included responsibility for the successful and profitable S-3A Viking, P-3C Orion, and Canadian CP-140 aircraft programs. In 1979, he became CALAC VP Operations, with a focus on reducing L-1011 TriStar production costs.

In 1981, Mr. Heppe went to Skunk Works as vice president and assistant general manager, with major involvement in the secret F-117 stealth fighter program. He also focused on Lockheed's design for the upcoming Air Force Advanced Tactical Fighter (ATF) competition.

In June 1984, he became president of CALAC, continuing his focus on ATF. He played a major role in establishing the Lockheed-Boeing-General Dynamics ATF team in 1986.

Besides being an AIAA Fellow, Mr. Heppe was elected as a member of the National Academy of Engineering. He was also honored with the AIAA Reed Aeronautics Award and the Admiral Charles E. Weakley Award from the National Security Industrial Association (1979).

AIAA Fellow Hoag Died in January

David G. Hoag died on 19 January 2015.

He served in the U.S. Navy, beginning when he was a student at MIT. From MIT he received an S.B. degree in Electrical Communications and an S.M. degree in Aeronautical Engineering Instrumentation. Mr. Hoag spent his entire career at the MIT Instrumentation Laboratory, which later became the Charles Stark Draper Laboratory.

Mr. Hoag is best known for his pioneering leadership on the development of the guidance, navigation and control systems for the Apollo command module and the lunar landing spacecrafts. He witnessed the first lunar landing from the VIP room of NASA's control center.

In 1951, he served as technical director of the Navy Polaris Missile Guidance System and then in 1961, as technical director and program manager of the Apollo Manned Lunar Landing Primary On Board Guidance System. In 1972, he became the department head of the NASA/Army Programs Department, and then of the Advanced Systems Department. Mr. Hoag was named a Senior Draper Fellow in 1977. In 1980, he became a technical advisor to the President of the C.S. Draper Laboratory and worked as a consultant for many years after his retirement.

Other professional affiliations included the Institution of Navigation (president, 1978–1979), the Defense Science Board, the AIAA New England section (chair, 1980–1981), the Navy Trident Flight Test Analysis Review Group (chairman, 1981), the Naval Studies Board Panel on Advanced Navigation Technology, and many national task groups involving navigation.

Mr. Hoag received the NASA Public Service Award in 1969, the Thurlow Award from the Institute of Navigation in 1969, "Laurels for 1969" recognition from *Aviation Week*, the Navy Certificate of Merit in 1970, a Special Award of the British Royal Institute of Navigation in 1970, the AIAA Lewis W. Hill Space Transportation Award in 1972, and election to both the National Academy of Engineering and the International Academy of Astronautics.

AIAA Fellow Duffy Died in February

Robert A. Duffy died on 15 February 2015.

B/Gen Robert A. Duffy, USAF (Ret.), enlisted in the U.S. Army as soon as he was old enough. Although physically disqualified for enlisted pilot training, Duffy was commissioned a second lieutenant in Aviation Ordnance in September 1942. He spent World War II stationed in Tunisia, Sicily, Selermo, and Foggia.

After the war, he served at Eglin Field with munitions and bombing equipment experiments until he received a regular commission. He was then sent to Georgia Tech by the newly-created U.S. Air Force, and he graduated in 1951. After a tour at MIT and General Motors, learning about how designs were created and transferred to production, Duffy worked at Wright Field developing bombing and navigation equipment for the B-47, B-52, and B-58. He eventually went on to the Command and Staff College.

After spending five years with the Space and Missile Development unit in Los Angeles, he was sent to the Defense

Department where, among other work, he establish a DDR&E field office in Vietnam. On his return, he was promoted and was assigned to the Space and Missile Systems Organization at Norton AFB to run the Re-entry Programs. His last military duty was as the vice commander of SAMSO, the parent organization in Los Angeles. At his retirement, he was awarded the 1971 Thomas D. White Space Trophy housed in the Air and Space Museum, and the Distinguished Service Medal.

Duffy then went to work at MIT's Instrumentation Laboratory. He became president of the Draper Laboratory, the successor organization, two years later, serving until 1986. Duffy was on a number of ad hoc committees and boards for NASA and Defense and became a U.S. delegate to the UNISPACE II Conference in Vienna in 1982. He served four years on the Defense Science Board and seven years on the Science and Technology Panel for the director of Central Intelligence. In 1984, he went to Antarctica for the National Science Foundation to examine and report on safety issues.

For a number of years, Duffy served on the Board of the Hertz Foundation, which annually supports nearly 100 doctoral candidates in Engineering and the Physical Sciences. He was President of the Institute of Navigation (1975–1976) and was awarded their Thurlow Award in 1965 for work on making inertial technology applicable to the military. He was elected as a member of the National Academy of Engineering in 1980 and served on many study panels. Having joined AIAA in 1974, he became a Fellow in 1981, and in 1986 was elected to The International Academy of Astronautics.

CALL FOR NOMINATIONS

Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 July**. Awards are presented annually, unless other indicated.

Any AIAA member in good standing may serve as a nominator and are highly urged to carefully read award guidelines (https://www.aiaa.org/Secondary.aspx?id=2915) to view nominee eligibility, page limits, letters of endorsement, etc. AIAA members may submit nominations online or download the nomination form after logging into www.aiaa.org with their user name and password.

Aerospace Design Engineering Award recognizes design engineers who have made outstanding technical, educational, or creative achievements that exemplifies the quality and elements of design engineering. (Presented even years)

Aerospace Guidance, Navigation, and Control Award recognizes important contributions in the field of guidance, navigation, and control. (Presented even years)

Aerospace Software Engineering Award honors outstanding technical and/or management contributions to aeronautical or astronautical software engineering. (Presented odd years)

Children's Literature Award is presented for an outstanding, significant, and original contribution in aeronautics and astronautics. (Presented odd years)

de Florez Award for Flight Simulation is named in honor of the late Admiral Luis de Florez and is presented for an outstanding individual achievement in the application of flight simulation to aerospace training, research, and development.

Excellence in Aerospace Standardization Award honors contributions by individuals that advance the health of the aerospace community by enabling cooperation, competition, and growth through the standardization process. (Presented odd years)

Faculty Advisor Award is presented to the faculty advisor of a chartered AIAA Student Branch, who in the opinion of student branch members, and the AIAA Student Activities Committee, has made outstanding contributions as a student branch faculty advisor, as evidenced by the record of his/her student branch in local, regional, and national activities.

Gardner-Lasser History Literature Award is presented for the best original contribution to the field of aeronautical or astronautical historical nonfiction literature published in the last five years dealing with the science, technology, and/or impact of aeronautics and astronautics on society.

History Manuscript Award is presented for the best historical manuscript dealing with the science, technology, and/or impact or aeronautics and astronautics on society.

Information Systems Award is presented for technical and/or management contributions in space and aeronautics computer and sensing aspects of information technology and science. (Presented odd years)

Intelligent Systems Award recognizes important fundamental contributions to intelligent systems technologies and applications that advance the capabilities of aerospace systems. (Presented even years)

Lawrence Sperry Award is presented for a notable contribution made by a young person to the advancement of aeronautics or astronautics. The nominee must be under 35 years of age on **December 31** of the year preceding the presentation.

Mechanics and Control of Flight Award honors an outstanding recent technical or scientific contribution in the mechanics, guidance, or control of flight in space or the atmosphere.

Pendray Aerospace Literature Award is presented for an outstanding contribution or contributions to aeronautical and astronautical literature in the relatively recent past.

Structures, Structural Dynamics and Materials Award is presented for an outstanding sustained technical or scientific contribution in aerospace structures, structural dynamics, or materials. (Presented even years)

Survivability Award recognizes outstanding achievement or contribution in design, analysis implementation, and/or education of survivability in an aerospace system. (Presented even years)

Summerfield Book Award is presented to the author of the best book recently published by AIAA. Criteria for the selection include quality and professional acceptance as evidenced by impact on the field, citations, classroom adoptions and sales.

Sustained Service Award recognizes sustained, significant service and contributions to AIAA by members of the Institute. A maximum of 20 awards are presented each year.

For more information on AIAA's awards program, contact Carol Stewart, Manager, AIAA Honors and Awards, carols@aiaa.org or 703.264.7623.

SCITECH 2016

4–8 JANUARY 2016 **SAN DIEGO, CA**

CALL FOR PAPERS

Drawing more than 3,400 participants from 42 nations, the AIAA Science and Technology Forum and Exposition (AIAA SciTech) is the single most important event for anyone involved in aerospace research and development.

Professional Exposure

When you present your paper at AIAA SciTech 2016, it will be archived in AIAA's Aerospace Research Central (ARC), where it will gain exposure to more than 2 million visitors each year from more than 200 countries around the world.

Students

Win cash, earn respect, gain skills when you participate in the six student paper competitions that take place at AIAA SciTech 2016.

Young Professionals

Build your resume, gain skills, and engage with experts in your field when you present a paper and participate in the Rising Leaders in Aerospace program.

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- 24th AIAA/AHS Adaptive Structures Conference
- 54th AIAA Aerospace Sciences Meeting
- AIAA Atmospheric Flight Mechanics Conference
- 15th Dynamics Specialists Conference
- AIAA Guidance, Navigation, and Control Conference
- AIAA Information Systems—Infotech@Aerospace Conference
- AIAA Modeling and Simulation Technologies Conference
- 18th AIAA Non-Deterministic Approaches Conference
- 57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference
- 9th Symposium on Space Resource Utilization
- 3rd AIAA Spacecraft Structures Conference
- 34th Wind Energy Symposium

DATES TO REMEMBER

Abstract Submission Opens: **17 March 2015**
Abstract Submission Closes: **15 June 2015**
Manuscript Deadline: **1 December 2015**

aiaa-scitech.org/callforpapers

AIAA
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15-639

AIAA Propulsion and Energy Forum and Exposition

Energize Innovation. Boost Value. Propel The Future.

27–29 July 2015
Hilton Orlando
Orlando, Florida

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Bob Hwang, Director, Transportation Energy Center, Sandia National Labs

*Complete list of organizers at **aiaa-propulsionenergy.org/Organizers***

Sponsors

Propulsion and energy systems are at the very heart of aerospace, whether you are flying passengers to London or satellites to LEO. Every move forward in our exploration of the world, and the universe, is enabled by new technologies coming from the researchers and engineers who will assemble together at the AIAA Propulsion and Energy Forum and Exposition 2015 (AIAA Propulsion and Energy 2015).

Plenary Program

Plenary sessions examine some of the most critical issues in propulsion and energy today. Plenary sessions will address:

- Global Cooperation and Economic Development
- Cost and Affordability of Future Systems
- Technology Development and Trends in Propulsion and Energy
- What does the Future Propulsion and Energy Workforce Look Like?

Forum 360

The Forum 360 panel discussions build on the themes and discussions of each day's plenary session, adding a layer of content and context that enhances the value of your forum experience. These conversations with experts will cover a spectrum of timely topics including:

- Aircraft Electric Propulsion
- Government Investments Enabling Advancement of In-Space Propulsion
- Infrastructure
- Role of Bio-fuels in Future Aviation
- Work/Life Balance Challenges for the 21st Century
- The Media and the Engineering Profession

Technical Program

Technical conferences meeting as part of Propulsion and Energy 2015 include the 51st AIAA/SAE/ASEE Joint Propulsion Conference and the 13th International Energy Conversion Engineering Conference. More than 700 abstracts have been submitted for presentation, providing the latest in innovative research and development in propulsion and energy. Browse, search, and create a personal agenda at **https://aiaa-MPE15.abstractcentral.com/itin.jsp**

Continuing Education

Register for one of the four continuing education courses and gain access to all forum activities. Plus, you will leave with invaluable improvements and solutions that you can put to immediate use.

- Advanced High Speed Air Breathing Propulsion
- The Application of Green Propulsion for Future Space
- Business Management for Engineers
- Hybrid Rocket Propulsion

Recognition

Join colleagues and friends in celebrating innovation and achievements in propulsion and energy at the AIAA Awards Luncheon. The following awards will be presented:

AIAA Aerospace Power Systems Award
AIAA Air Breathing Propulsion Award
AIAA Energy Systems Award
AIAA Engineer of the Year Award
AIAA Propellants and Combustion Award
AIAA Wyld Propulsion Award
Certificate of Merit for Best Papers

Rising Leaders in Aerospace

The multidimensional program for young aerospace leaders features a speed mentoring leadership exchange, panel or keynote session, Q&A with top industry leaders, and multiple opportunities for networking.

2015 Exhibitors

Exhibit and sponsorship opportunities available. See aiaa-propulsionenergy.org for more information.

- Aerojet Rocketdyne
- Beta CAE Systems USA, Inc.
- Cambridge University Press
- Cobham
- Desktop Aeronautics
- dSpace, Inc.
- EKK Eagle Industry, Co. LTD.
- GE Aviation
- General Dynamics - OTS
- Intelligent Light
- JASC-Controls
- Marotta Controls, Inc.
- Metal Technology
- Moog, Inc
- National Aeronautics and Space Administration (NASA)
- National Technical Systems (NTS)
- North Star Imaging, Inc.
- Orbital ATK
- Poco Graphite
- Pointwise, Inc.
- Rolls-Royce
- Stanford Mu
- Tecplot, Inc.
- Vacco Industries
- Valcor Engineering Corporation
- Wolverine Ventures, Inc.
- Worthington Industries (SCI)

Plan Your Trip

Hilton Orlando
36001 Destination Parkway
Orlando, FL 32819
Phone number: +1.407.313.4300

AIAA has made accommodations for a block of rooms at the Hilton Orlando. Room rates are $199 plus 12.5% tax for a standard room (single or double occupancy). These rooms will be held for AIAA until **6 July 2015**, or until the room block is full, then released for use by the general public. Book your hotel at **aiaa-propulsionenergy.org/Planyourtrip**.

Register Today

AIAA Members save $350 when they register by **13 July 2015**.

aiaa-propulsionenergy.org/register

Aerospace Spotlight Awards Gala

Wednesday, 6 May 2015, Washington, D.C.

Join us for a spectacular evening of recognition and celebration!

Distinguished Service Award
Roy Harris, Consultant/Retired NASA Director

Goddard Astronautics Award
Jean-Jacques Dordain, European Space Agency

International Cooperation Award
Andreas Schuette, DLR

Russell Cummings, U.S. Air Force Academy

Public Service Award
Congressman Ralph Hall, 4th District Texas (1980-2015)

Reed Aeronautics Award
Ramesh Agarwal, Washington University in St. Louis

Daniel Guggenheim Medal
Alan R. Mulally, Former Executive Vice President, The Boeing Company

AIAA Foundation Award for Excellence
X-37B Orbital Test Vehicle

AIAA Foundation Educator Achievement Awards
Mohamad Barbarji, West Point High School, West Point, Virginia

Gary Garber, Boston University Academy, Boston, Massachusetts

Kaci Heins, Northland Preparatory Academy, Flagstaff, Arizona

Heather Stewart, Paxton School, Paxton, Florida

Paul Wiedorn, Wilde Lake High School, Columbia, Maryland

AIAA National Capital Section Barry M. Goldwater Educator Award
Christopher Scolese, NASA Goddard Space Flight Center

We will also recognize the Class of 2015 Fellows and Honorary Fellows.

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AIAA
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15-579

Upcoming AIAA Continuing Education Courses

Courses at AIAA Aviation and Aeronautics Forum 2015 (AIAA AVIATION 2015)
www.aiaa-aviation.org/ContinuingEd

20–21 June 2015

Optimal Design in Multidisciplinary Systems **(Instructors: Joaquim R. R. A. Martins and Jaroslaw Sobieski, Ph.D)**

When you are designing or evaluating a complicated engineering system such as an aircraft or a launch vehicle, can you effectively reconcile the multitude of conflicting requirements, interactions, and objectives? This course introduces you to methods and tools that have been developed over the years for the design optimization of engineering systems.

You will be presented with a review of the state-of-the-art methods for design optimization that exploit the modern computer technology for applications with large numbers of variables, and design constraints. You will learn how to evaluate sensitivity of the design to variables, initial requirements, and constraints, and how to select the best approach among the many that are currently available.

The last part of the course will take you to system-level applications where the primary problem is in harmonizing the local disciplinary requirements and design goals to attain the objectives required of the entire system, and where performance depends on the interactions and synergy of all its parts. In addition to imparting skills immediately applicable, the course will give you a perspective on emerging methods and development trends.

Key Topics
- Multidisciplinary design-components, challenges, and opportunities
- Optimization methods
- Sensitivity analysis
- Decomposition architectures in multidisciplinary design
- Surrogate modeling in design
- Soft computing methods in optimal design

FUN3D Training Workshop

Please note that FUN3D is export-controlled software and may only be provided to U.S. persons.

This workshop will provide participants with guidance on how to install and execute the NASA Langley Research Center FUN3D computational fluid dynamics software for common aerospace applications. The objective of this workshop is to provide engineers and scientists with sufficient instructions to apply a large-scale Navier-Stokes solver to their analysis and design applications of interest. Detailed instructions will be provided for topics including analysis of steady and unsteady flow, boundary conditions, application to dynamic and overset mesh simulations, adaptive gridding, aerospace computations, geometry parameterization, and adjoint-based design optimization.

Courses at AIAA Propulsion and Energy Forum 2015
www.aiaa-propulsionenergy.org/ContinuingEd

25–26 July 2015

The Application of Green Propulsion for Future Space **(Instructors: Alan Frankel, Ivett Leyva, Patrick Alliot)**

Liquid propulsion systems are critical to launch vehicle and spacecraft performance and mission success. This two-day course, taught by a team of government, industry, and international experts, will cover propulsion fundamentals and topics of interest in launch vehicle and spacecraft propulsion, non-toxic propulsion drivers, propellants and figures of merit, applications of non-toxic propulsion, flight experience, and advances in smallsat propulsion. Lessons learned from development and flight of components and systems will be discussed.

Key Topics
- Rocket propulsion fundamentals
- Structural considerations in rocket engine design
- Rocket engine testing
- Development and flight experience with green monopropellants
- Microsat, nanosat, and cubesat propulsion
- Dual mode engines and propulsion system trades

Advanced High Speed Air-Breathing Propulsion **(Instructors: Dora E. Musielak, Marty Bradley, Stephen Beckel, J. Phil Drummond)**

Revolutionary methods of high speed air-breathing propulsion are needed to extend the flight regime of aircraft, missiles, and improve Earth-to-orbit spacecraft. Advanced High Speed Air-Breathing Propulsion will introduce students to the design and development processes of high speed propulsion, including ramjet/scramjets and TBCC concepts. The course will present a comprehensive overview of the state of the art, including highlights of current high speed propulsion programs in the world. An introduction to multidisciplinary design optimization (MDO) will help students appreciate the challenges of developing this breakthrough propulsion technology.

The instructors are actively engaged in high-speed propulsion R&D. They will discuss the challenges, and development trends and future of the propulsion technologies needed to make truly high speed flight a reality. This course is sponsored by the AIAA High Speed Air Breathing Propulsion Technical Committee (HSABP TC).

Key Topics
- Mission requirements
- Combined cycle propulsion concepts
- Ramjet/scramjet inlet design

- Ram/scramjet combustion structural design
- Fuels and thermal management engine/airframe integration, TBCC integration
- Advanced materials
- CFD modeling and simulation of high speed reacting flow
- Propulsion multidisciplinary design optimization (MDO)
- High speed propulsion ground and flight testing

30–31 July 2015

Business Management for Engineers **(Instructors: Alan C. Tribble and Alan Breitbart)**
This course will help individuals with a technical background master the business principles that guide the leadership of an engineering-oriented company. The course will prepare students for the transition from the role of a technical contributor to that of a business leader.

Key Topics
- Capitalism and free markets
- Business finance
- Business structure and functions
- Relationship between systems engineering and program management
- Communicating for business impact versus technical
- Globalization

Hybrid Rocket Propulsion **(Instructor: Dr. Joe Majdalani)**
This course reviews the fundamentals of hybrid rocket propulsion with special emphasis on application-based design and system integration, propellant selection, flow field and regression rate modeling, solid fuel pyrolysis, scaling effects, transient behavior, and combustion instability. Advantages and disadvantages of both conventional and unconventional vortex hybrid configurations are examined and discussed.

Key Topics
- Introduction, classification, challenges, and advantages of hybrids
- Similarity and scaling effects in hybrid rocket motors
- Flowfield modeling of classical and non-classical hybrid rockets
- Solid fuel pyrolysis phenomena and regression rate: Mechanisms & measurement techniques
- Combustion instability and transient behavior in hybrid rocket motors
- Metals, other energetic additives, and special binders used in solid fuels for hybrid rocket applications

Courses at AIAA Space and Astronautics Forum 2015 (AIAA SPACE 2015)
www.aiaa-space.org/ContinuingEd

29–30 August 2015

Introduction to Space Systems **(Instructor: Dr. Mike Gruntman)**
This course provides an introduction to the concepts and technologies of modern space systems. Space systems combine engineering, science, and external phenomena. We concentrate on scientific and engineering foundations of spacecraft systems and interactions among various subsystems. These fundamentals of subsystem technologies provide an indispensable basis for system engineering. The basic nomenclature, vocabulary, and concepts will make it possible to converse with understanding with subsystem specialists.

Key Topics
- Space enterprise
- Solar system
- Coordinate systems
- Space environment and spacecraft interaction
- Basics of orbital mechanics
- Common orbits and space mission geometry
- Mission support systems
- Space mission overview
- Spacecraft propulsion
- Launch systems
- Attitude determination and control
- Space communications
- Spacecraft power systems and thermal control
- Space missions and applications



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